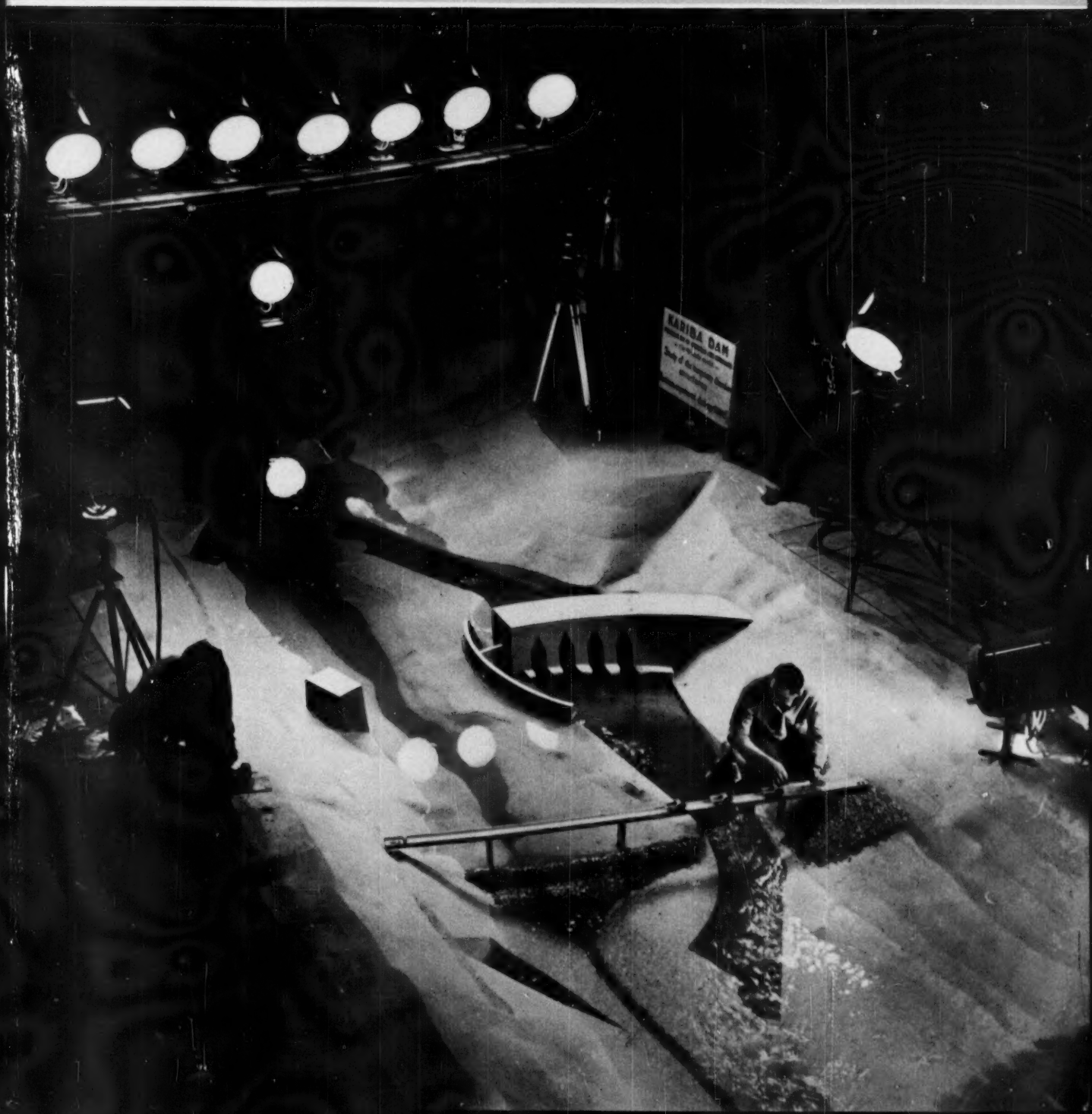
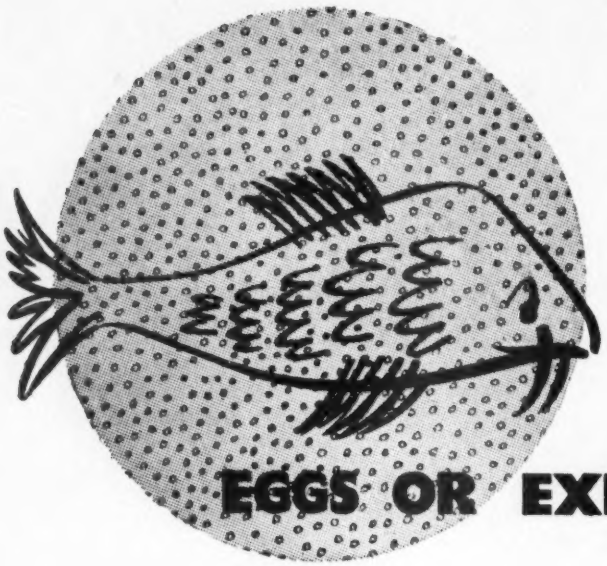
52

DISCOVERY

MAY 1958 2/6





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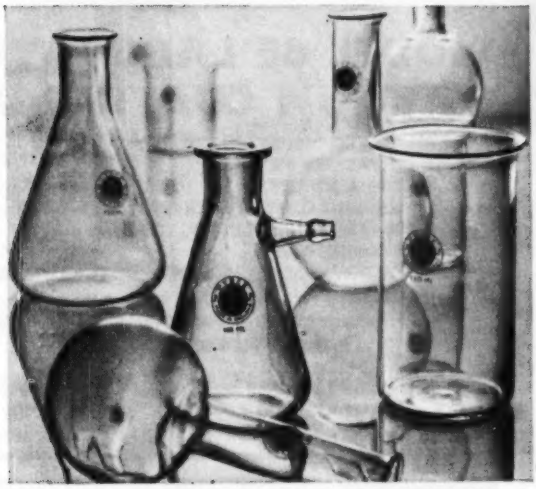

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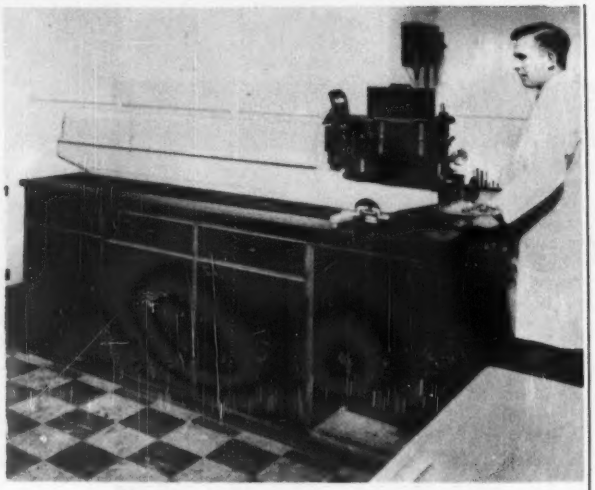

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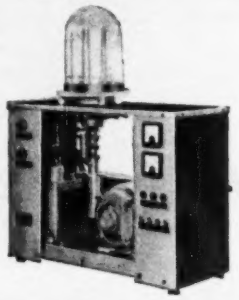

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OUR COVER PICTURE

Scale model of Kariba Dam, Southern Rhodesia, at the Société Grenobloise d'Etudes et d'Applications Hydrauliques (SOGREAH). The scale model gives scientists constant and reliable assistance in the study of water (see pp. 188–92.)

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THE PROGRESS OF SCIENCE

THE SCIENCE OF SATIRE

Is it possible to investigate "irrational" phenomena by "rational" methods? Freud, it is true, succeeded in probing the irrational psyche by methods which are themselves free from irrationality. But the political and social scientists are apt to assume that the social phenomena which it is their business to elucidate are invariably as "rational" as their methods of elucidation. If, then, we feel that their achievement falls somewhat short of their aspiration it may be because certain social processes can only be identified by someone with a satirical turn of mind, untrammelled by the lore of political and social science. This is the moral of "Parkinson's Law."*

Prof. Parkinson's fundamental law is that work expands so as to fill the time available for its completion. This is based on two axioms, namely, (i) an official wants to multiply subordinates, not rivals, and (ii) officials make work for one another. A majestic hypothetico-deductive system, verifiable by experiment, could be erected on these axioms. Prof. Parkinson goes on to enunciate the principles of personnel selection by judicious advertising, formulates rules for the effective functioning of parliaments and conferences, establishes the psychophysics of finance, derives an infallible formula for success, reveals the inverse relationship between institutional effectiveness and the mausoleum in which it becomes enshrined, and finally fixes the age of other people's retirement.

His satirical technique enables him to present his subject in a perspective which would be impossible to achieve in any other way without making oneself look ridiculous. Take, for instance, the important question of cocktail parties at international, scientific, and industrial congresses. No self-respecting social scientist is likely to study their diagnostic uses by determining the precise times at which luminaries arrive and disappear or the manner and velocity of their locomotion through the party.

Parkinson's shafts unerringly find their Achilles heel. Unlike the hypotheses of social science they do not rebound blunted from the shining armour of their target. Only a born satirist would be capable of perceiving that truest of all distinctions between committees, that is, between those from which the individual member has something to gain and those to which he merely has something to contribute. Again, only the qualified satirist could perceive that the second category scarcely merits the title "committee". Perhaps the essential difference between the political or social scientist and the satirist is that the former takes *himself* and the latter his *task* seriously.

A feature of social, psychological, and political scientists is their ardent wish to be ethically and morally neutral. So they eschew any value judgments. Because they pass no judgments on a man's character, they ignore it completely. Thus the state of mind commonly known as jealousy is not supposed to exist in public administration. Nevertheless Prof. Parkinson is able to describe the havoc created by jealousy in administrative, commercial, and academic institutions, and he describes a peculiar disability due to the fusion of incompetence and jealousy, which he designates *Ingelititis*.

After due percussion and palpation Prof. Parkinson places his healing finger on a grave scrofula of social institutions. This occupational disease might be described as institutional stereotypy. Neither government departments nor centres of higher learning are immune. In the advanced stages of the disease, the institution tends to perpetuate itself while undergoing a continuous degeneration until it finally atrophies.

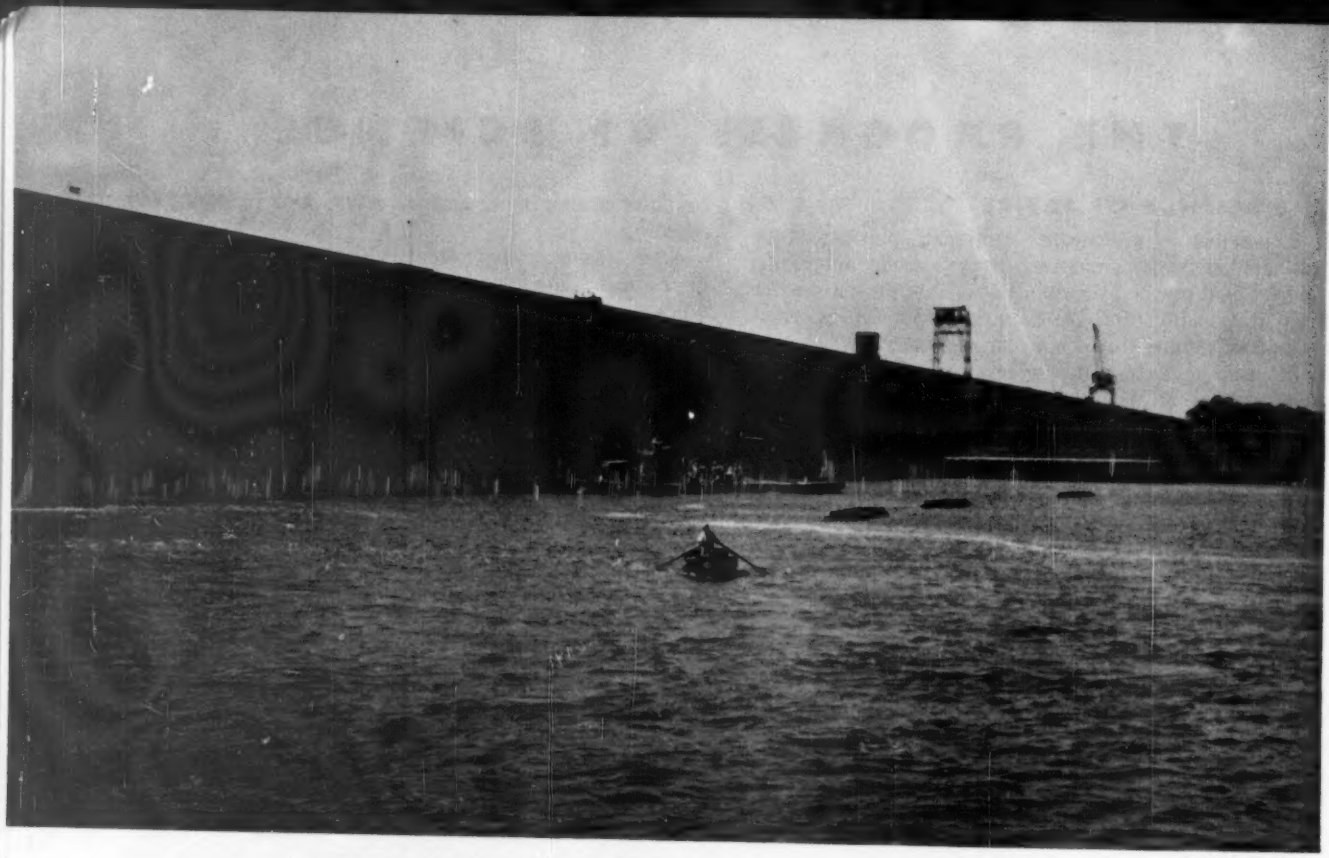
Prof. Parkinson follows a distinguished line of satirical predecessors. We are reminded particularly of the celebrated de Morgan's "Budget of Paradoxes" published a century ago, and of J. A. Hobson's sagacious "Free Thought in the Social Sciences". Among contemporaries Prof. Parkinson would find a kindred spirit in William H. Whyte, author of "The Organisation Man", a luridly brilliant description of the millstone round the neck of American science and bureaucracy. Every student of "Parkinson's Law" should certainly master Mr Whyte's technical Appendix entitled "How to Cheat on Personality Tests".

The enterprising searcher for truth, after a diligent study of "Parkinson's Law", will doubtless be inspired to ask a number of novel and exciting questions. What, he may wonder, is the secret of "empire-building" in certain academic and other departments whereby they acquire huge staffs, vast funds, palatial accommodation, and magnificent equipment while others, at least equally productive, are left starving and poverty-stricken in dark and dusty attics?

The University Grants Committee might be invited to show its recognition of "Parkinson's Law" by endowing the universities of this country with chairs of satirical science. If so, one feels sure that Parkinson would prefer them to be located in the faculties of medicine or music where the incumbents might escape the danger of losing their identity and thus rendered innocuous in the homogenising dough of social science.

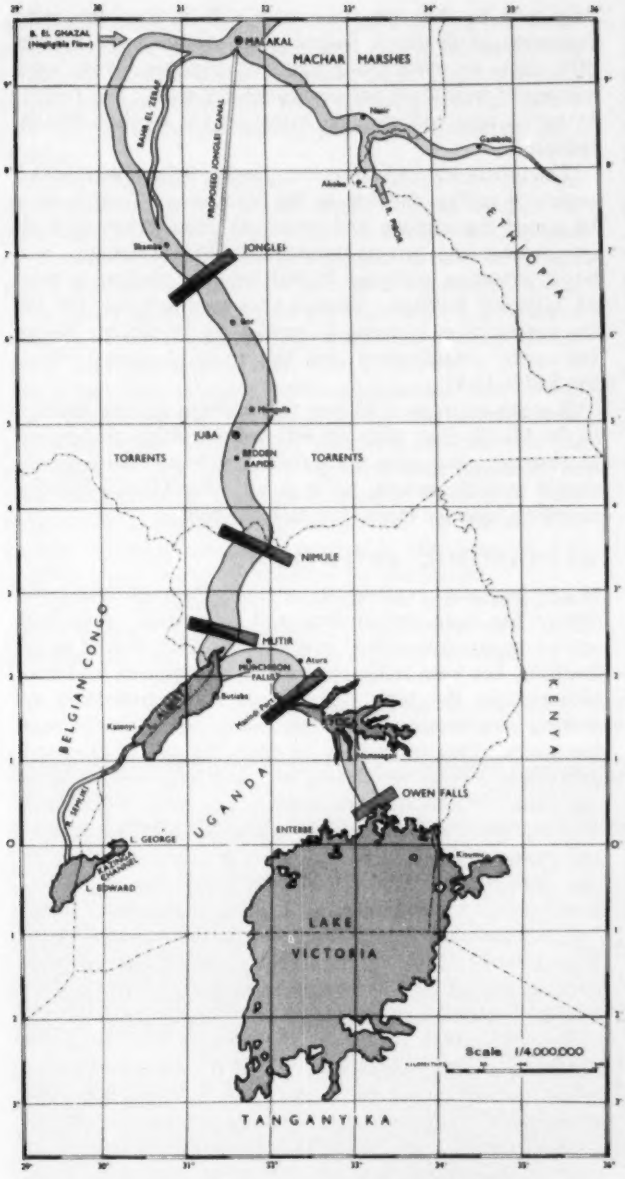
Finance Committee meetings operate on Prof. C. N. Parkinson's Law of Triviality: "The time spent on any item of the agenda will be in inverse proportion to the sum involved." *(An illustration by Osbert Lancaster.)*

* "Parkinson's Law, or the Pursuit of Progress", by Prof. C. Northcote Parkinson (John Murray, 1958, 12*s*. 6*d*.).



Sennar Dam.

Machine used for clearing weeds.



The Tropical Nile, Southern Section.

IRRIGATION IN SUDAN REPUBLIC

It is the belief in some quarters that the strained relations between Egypt and Sudan resulted mainly from the breaking-off, until after the elections, of the Nile waters talks early in February. Egypt and Sudan had agreed in principle to pay compensation for the flooding of the town of Wadi and the surrounding Sudanese territory. Up to the time we went to press no agreement had been reached on the actual amount, but Egypt's finances are in no position to pay large-scale compensation. Up to that time also, no agreement had been reached on the actual allocation of the Nile waters. So far Sudan has been insisting that the Nile waters be divided on a basis proportional to the population, although a lesser percentage of the Sudanese population is dependent on the Nile.

Sudan Republic is a vast, sun-parched land of 1 million square miles. It has a population of 10,262,536, increasing at the rate of 3·3% a year (the highest birthrate reported in the world except Brunei and Guam according to the 1955 Sudan census).

Only one-fifth of its area can rely on a rainfall of 30 in. three years out of four. In the northern third the rainfall averages less than 6 in., and only by artificial irrigation is agriculture possible at all. Even in the central zone the rains are so variable that at least supplementary irrigation is necessary to mature most types of crops.

Half a century ago, irrigation in Sudan extended to little more than the area watered by the traditional methods of Sagia and Shaduf, perhaps 100,000 feddans in all (1 feddan =1·038 acres). Now, using various methods in different parts of the country, it commands a total gross area of 2½ million feddans, of which about 1¼ million bear crops each year.

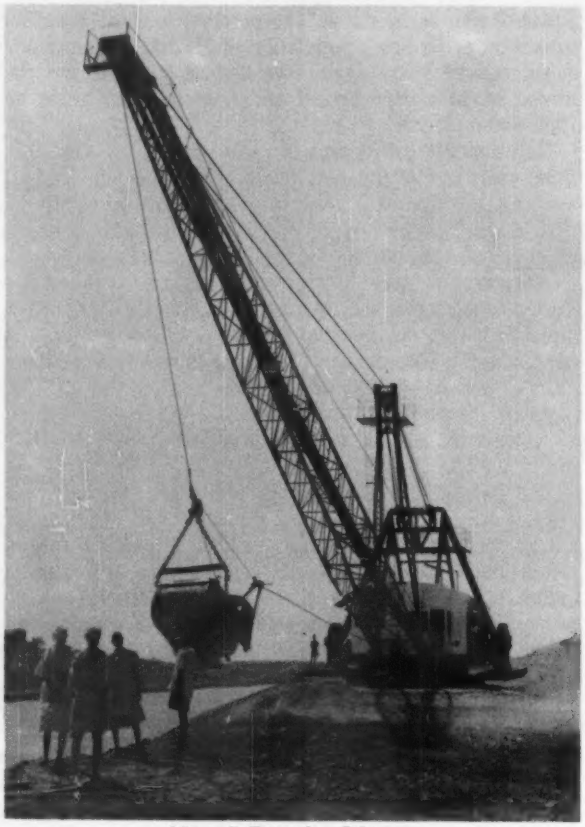
The Nile is the jugular vein of Sudan. Its two main arteries are the White Nile and the Blue Nile. The former, fed by the Bahr-el-Jebel, rises in Uganda and flows sluggishly but regularly through the swamps of southern Sudan while the latter rushes seasonally down from the mountains of Ethiopia. The rivers join at Khartoum forming the Main Nile which flows on towards the Egyptian border.

In order to provide for its rapidly increasing population Sudan has embarked on an ambitious plan for the utilisation of the Nile waters. Already two major dams exist in Sudan. The Jebel Aulia Dam which impounds over 3 milliard cu. m. of water for the benefit of Egypt and the Sennar Dam which supplies the Sudan Gezira Scheme. This dam was completed in 1925. It is 3025 m. long and its canalisation system carrying water to the cotton covers 7549 km.

Since 1950 the Gezira Scheme has been administered as a public corporation which is independent of political control. It is the largest co-operative enterprise under one management in the world. It covers a gross area of 1 million feddans of which some 250,000 feddans are under cotton cultivation annually. Another 250,000 feddans are reserved for other crops while the remaining 500,000 feddans lie fallow. It has developed a type of regulator and a system of night storage of water unique to Sudan. Over 50% of the nation's income is derived from the Gezira Scheme while its 27,000 tenants are the richest peasant farmers in the Middle East.

The Managil Extension Scheme will increase the area under irrigation in the Gezira by 800,000 feddans. The Scheme is divided into four stages of approximately 200,000 feddans. Originally it was planned to complete the new area in seven years but owing to the nation's urgent need for capital for future development, the Ministry of Irrigation, working under the direction of the Minister, Sayed Mirghani Hamza, himself an engineer, devised a new plan which has reduced the schedule from seven years to four years. The first stage of 208,000 feddans has already been completed ahead of schedule.

This will be irrigated by a small branch canal of 40 cu. m./sec. capacity, from the main Gezira canal. This small canal will exhaust all the water capacity of the main Gezira canal. Meanwhile, the German firm of Julius



Managil Extension Scheme.

Berger and Phillips Holzman Ltd are building another main canal, under contract, from Sennar Dam with a capacity of 186 cu. m./sec., to irrigate the remaining 600,000 feddans.

Of this capacity, 118 cu. m./sec. will be used to irrigate the Managil. The remaining 68 cu. m./sec. will be used to alter the crop rotation of the Gezira from a four-crop rotation to a three-crop rotation, thus increasing the area under cotton cultivation in the original Gezira Scheme from one-quarter to one-third of the total area of 1 million feddans. The Managil Extension will therefore increase the area under cotton cultivation on the Gezira plain by approximately 350,000 feddans—well over 50% of that under cotton cultivation at present.

The next step in the plan is the construction of the Roseires Dam on the Blue Nile near the Ethiopian border. The dam has been designed by Sir Alexander Gibb and Partners of London (Consulting Engineers to the Ministry of Irrigation and Hydro-electric Power) in association with M. André Coyne of Paris. The central sluice will be of the heavy buttress type and about 900 m. long. It will be flanked by embankments with an aggregate length of nearly 8 km. The surface of the full reservoir will be some 480 m. above sea-level, and will hold about 3 milliard cu. m. of water. It is intended to start work on the dam next year. On completion, this dam will irrigate the projected Kenana Extension of 1,600,000 feddans.

Other proposed irrigation schemes are the Atbara River Diversion Scheme which will irrigate 500,000 feddans, and the Jonglei By-pass Canal. The Jonglei canal on the White Nile will be 300 km. long and will by-pass the sudd (swamps) of southern Sudan, thus avoiding the present 50% loss—by evaporation and transpiration—of the total volume of water that passes through the sudd. The Jonglei by-pass Canal will provide irrigation for another 500,000 feddans.

Thus, existing and proposed gravity irrigation schemes cover 4·4 million feddans in the Nile basin. To this must be added the existing and proposed pump schemes, both government and private, covering 2,530,000 feddans, and basin irrigation covering 90,000 feddans, making a total of 7,020,000 feddans. Various sites on the main Nile for the construction of dams to provide hydro-electric power are under consideration, but this requires capital which the Sudan lacks.

It seems an irony of history that perhaps the one country in the Middle East with the will and the ability to develop its resources and raise the standard of living of its people should lack the means, while many other Middle Eastern countries have the means but lack the will.

ULTRASONIC AGITATION

Much post-war exploration of the scope of ultrasonic energy has been undertaken, and few fields of applied science have not benefited in some way. One, that of metal finishing, has been fairly extensively investigated, and notwithstanding the high cost, shows every indication of making considerable use of this energy source in the next few years. This technology involves the use of chemical solutions for such operations as electroplating, cleaning, and chemical immersion treatments. The reactions between solution and metal surface are invariably both accelerated and increased in efficiency by agitation of the liquid which was hitherto achieved mechanically by stirrer, or by bubbling air through the bath. Now it has been found that the passage of high-frequency sound-waves at from 20 to 1000 kc/s through the liquid results in a much more uniform and altogether more effective form of agitation.

The ultrasonic agitation of a liquid is itself basically a mechanical action, which can be resolved into two parts. First, there is the extremely vigorous micro-turbulence induced by the passage of the very rapidly alternating sound-waves. Then arising from this is a macro-turbulence known as cavitation, which derives from the formation of voids in the solution in the vicinity of cavities in the work. These voids collapse with the momentary dispersion of considerable energy.

In metal-treatment solutions the function of agitation is to supplement diffusion and convection in maintaining the film of solution in contact with the metal at virtually the same composition as the bulk of the solution: it also serves to remove the rather tenaciously adhering gas bubbles liberated during reactions. In small-scale electroplating experiments ultrasonic agitation has enormously increased the permissible speed of deposition by ensuring that the film of solution in actual contact with the cathode is replenished with metal ions as fast as they plate out. Unfortunately, and paradoxically, comparatively little practical use of this apparently substantial development can be made at present since the plating speeds attainable are too great for the comfortable operation of a small plant (bearing in mind that the fullest advantage of the increased

speed must be taken to justify the high cost of the ultrasonic generator). On the other hand, where full use of the exceptional speeds could be made, as in the continuous plating of sheet metal and wire, the output is on such a scale as to render the cost of generator completely prohibitive.

Where ultrasonic agitation can at present be employed is in small-scale, high-grade metal cleaning operations. Here the scrubbing action which so effectively displaces gas bubbles also dislodges the minutest particles of grease, swarf, and abrasive from the narrowest interstice or blind hole. Cleanliness of an extremely high order is demanded today in precision engineering such as the manufacture of watch and instrument parts, small ball-races, sensitive valves and fuel injectors, servo-mechanisms, and so on. The application of ultrasonic energy to conventional solvent or chemical cleaning solutions achieves this far more rapidly and completely than previous methods. So high, in fact, is the standard attainable that watch parts have to be artificially "recontaminated" by stearic acid vapour, since the interfacial tension is otherwise too low to allow the retention of watch-oil for lubrication.

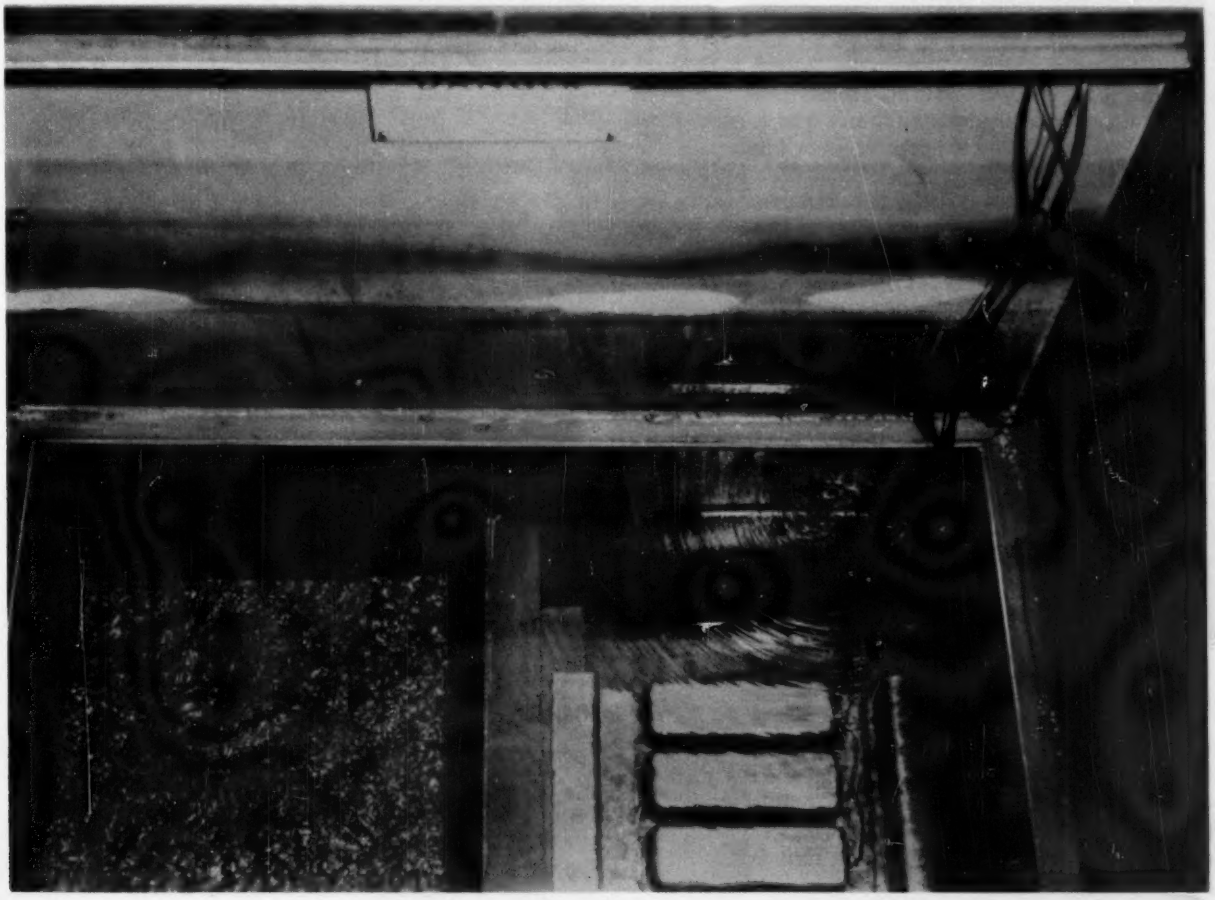
There are three methods available for generating ultrasonic waves: electro-magnetic, magneto-strictive, and piezoelectric; the most important here is the latter. The others are restricted by frequency limitations and by low electrical efficiencies, although magneto-strictive methods are used efficiently for frequencies of 20–170 kc/s, and these have lately been found of equal value to the high ones. Normally, however, the required frequency ranges from 100 to 400 kc/s. The energy is produced by a high-voltage valve oscillator feeding a power amplifier, this generator being by far the most costly item of the plant and increasing in cost roughly in proportion to its output.

In the piezoelectric system a transducer, a material which changes its dimensions slightly under the influence of an applied alternating voltage, is mounted in the base of the treatment tank. This is usually of barium titanate, and is shaped to focus the energy on to the contaminated work, a point of especial importance since the energy is rapidly dissipated.

The liquid cleaning medium is usually a warm organic solvent such as trichlorethylene, which, since the sound-waves are quickly absorbed by solids, must be kept substantially free from suspended matter. The work, roughly equal in area to the transducer, is immersed in baskets or on jigs, normally for a half or one minute. Here, then, we have, if not a new industrial cleaning process, certainly a considerable refinement, and one which promises no little development.

Internal view of a degreasing plant showing the ultrasonic transducers. The clarity of the degreasing fluid is maintained by circulating it through a 10μ filter.

(Courtesy, G. S. Blakeslee & Co., U.S.A.)



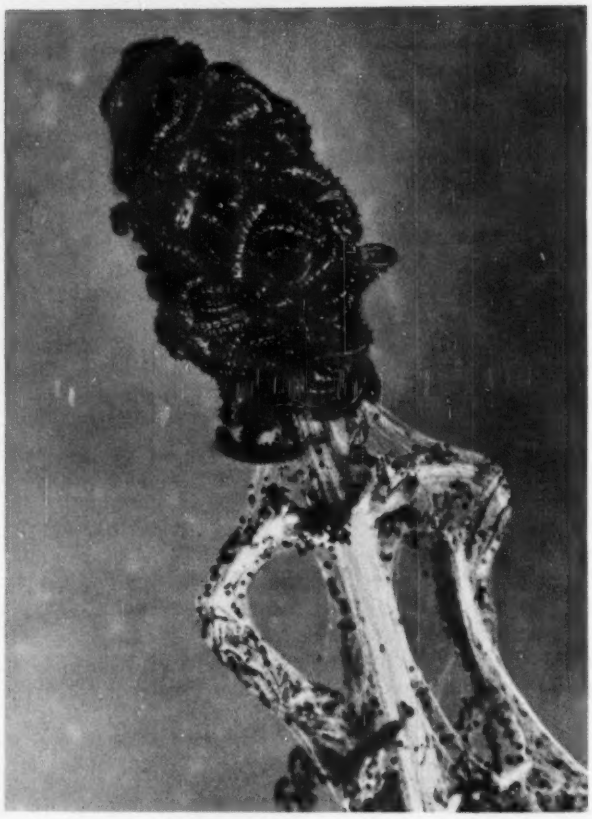
THE GREGARIOUS HABITS OF SOME CATERPILLARS

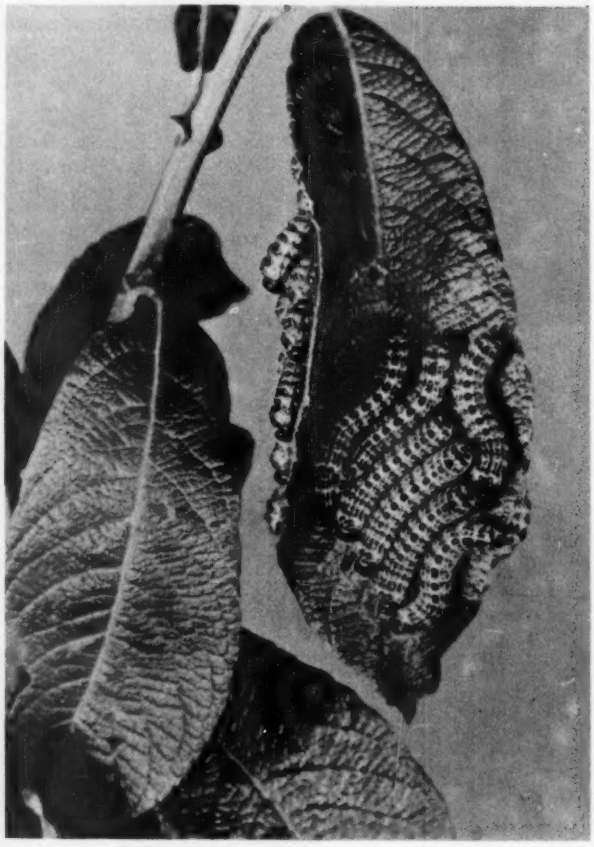
Of the many different kinds of caterpillars that feed in the spring and early summer there are some that have gregarious habits and lead communal lives. This applies to several common species which are easily found, and it is not unusual to hear of the discovery of a "nest of caterpillars". Among the butterfly caterpillars that live in company are those of the small tortoiseshell, which feed on stinging nettle and cover the plants with masses of greyish web. The rarer large tortoiseshell behaves in a somewhat similar way in the larval stage, but the caterpillars prefer a diet of elm, and usually feed fairly high up, where they are easily overlooked. The blackish, spiny caterpillars of the peacock butterfly also live on stinging nettle, and they too form communities. Turning to the moths, the tough, weather-resisting silken webs constructed by the caterpillars of the common lackey and the small eggar moths can be seen in hedgerows in May and June. These "nests" are commonest among hawthorn and blackthorn, and sometimes appear on orchard trees. Well over a hundred caterpillars may live in a single nest, but it is unusual to find the entire colony on view at the same time. Some individuals may be resting on the outside of their homes, others will be inside, hidden by the dense, silken walls.

Later in the summer, family parties of the yellow and black-striped caterpillars of the buff-tip moth are a common sight. They feed on a variety of trees, including birch, oak, and elm; and sometimes as many as fifty are seen closely huddled together for the delicate process of changing their skins. On approaching maturity, they tend to wander, but it is not unusual to see a dozen or more adults eating the leaves of the same twig.

Considering that the majority of caterpillars, both butterfly and moth, lead a solitary existence, it is natural to inquire what advantage, if any, is derived from communal life. It should be remembered that many species of butterflies and moths lay large batches of eggs, and that the caterpillars hatching from them separate quickly. Why, then, should a few kinds remain in company throughout life? There appear to be a few obvious advantages in communal living, when a web or shelter is shared. This provides some protection from severe weather, and also from certain enemies, but it does not save the inmates from their deadly foes, the ichneumonflies and their allies. All caterpillars, gregarious or otherwise, are attacked. Again, the caterpillars of the buff-tip moth and the large white butterfly, another gregarious species, do not construct any form of shelter, and are exposed to enemies. Furthermore, it must be admitted that where caterpillars resort together they are usually far more conspicuous than single individuals.

The whole subject of gregarious living in caterpillars invites investigation. It is possible that some species now living a solitary life were once gregarious, and that those we know as communal caterpillars have only acquired the habit in comparatively recent times. The serious study of entomology is not very old, and reliable records dating back more than 150 years are few.

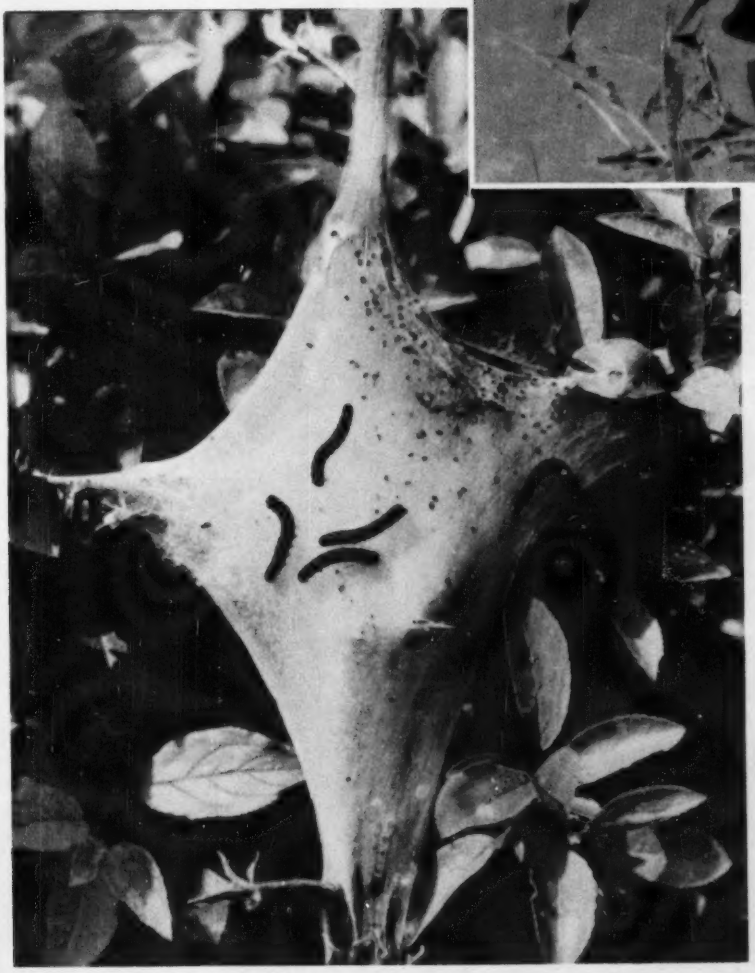




(*Above, left*) A colony of small tortoiseshell butterfly caterpillars on stinging nettle. (About natural size.)

(*Below, left*) Caterpillars of the buff-tip moth preparing to change their skins. (About natural size.)

Caterpillars of the small eggar moth about half grown. (Natural size.)



Web and caterpillars of common lackey moth on blackthorn. (Natural size.)

ELECTRIFICATION
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(All photographs by courtesy of British Railways)

(Above) Erecting an overhead steel structure into holes drilled by the auger borer.

(Above, left) Running out the overhead cables.

(Left) The auger borer made by British Insulated Callender's Construction Co. Ltd.

MECHANISATION SPEEDS UP ELECTRIFICATION

British Railways have decided to modernise (after many years of stagnation, as far as technical development is concerned) and the tempo of electrification is now beginning to build up.

Prior to the Second World War, the price of coal in this country was so low that the electrification of British Railways did not appear to be an economic proposition and it was only on a limited scale that electrification was carried out by the various independent Railway Companies. Many of the small schemes were really in the nature of experiments, with the exception of the Southern Railway, and electrification of certain other minor lines at 600 volts D.C., third rail. Until electrification of a whole system is carried out the economic advantages cannot be fully gained.

Today with the price of first-grade coal, such as is used in steam locomotives, at a very high level and more and more electric power becoming available from Atomic Power Stations, electrification of the railways appears to be an economic proposition, in fact an absolute necessity if the railways are going to survive in the future.

Within the next twelve years, a large portion of the London Midland Region will be electrified, together with a considerable area in the Eastern Region of British Railways. In addition a number of suburban lines in the Glasgow area will also be converted to an electrified system.

All the electrification now being carried out in this country, with the exception of certain extensions to the Southern Region, 600 volts D.C. system, will be at 50 cycles A.C., supplied directly from the Central Electricity Generating Board's 132 kV grid-system. The supply being normally taken at 25,000 volts, although in certain areas it has been necessary, due to insufficient clearance to bridges being obtainable, for the overhead line equipment to be energised at 6520 volts.

In order to carry out this enormous task of altering the face of British Railways a number of new plants have been developed.

A new concrete-mixing unit which can produce concrete continuously as it moves along the railway tracks went into operation recently on a section of the line to be electrified near Crewe. It has been added to the special electrification works trains, developed to erect steel supports for the overhead conductor wires on the lines between Euston, Birmingham, Liverpool, and Manchester, in the London Midland Region's Main Line Electrification project.

The concrete-mixing unit (a BICC machine mounted on railway waggons) carries its own supply of cement in bulk. It is supplied with sand and gravel from 50-ton hopper waggons, which are coupled to the unit, and with water from a water-carrying vehicle coupled to the opposite end of the unit. The sand and gravel are fed through to the mixing unit by means of a system of conveyor-belts driven electrically from a generator van also attached to the train. All the ingredients are fed into a rotating screw, which ensures correct measures of sand and gravel, and correct quantities of cement and water are then added, and as the substance is forced along the concrete-mixers it is fully mixed and delivered to the outlet spout in its correct consistency. The resultant mixture can either be poured out through a

movable spout direct to a lineside job or alternatively supplied to a special placing unit situated alongside the mixer. This placing unit can store the concrete and also deliver it through a spout of its own. Thus for filling large foundations, both the placing unit and the concrete-mixer can deliver concrete simultaneously.

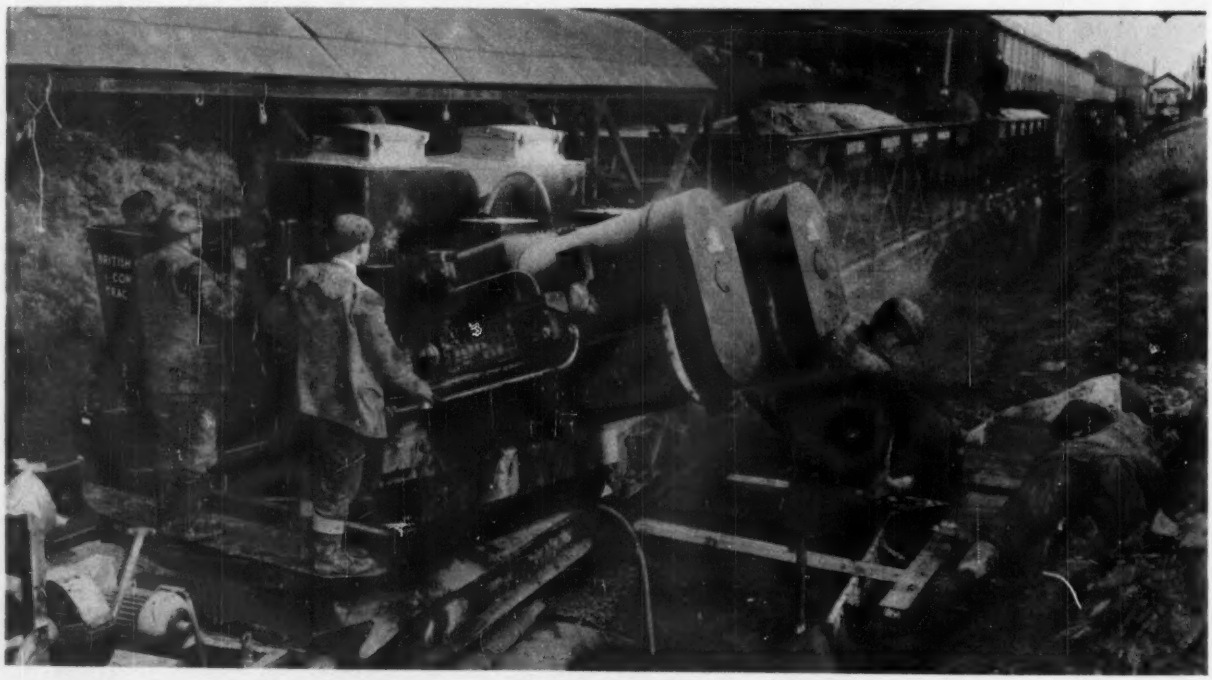
This new concrete-mixing unit, in conjunction with the other electrification works trains, can be used to erect the steel masts for the overhead equipment in a continuous operation as the trains pass along the track. Trains can plant a mile of masts on one side of the track in a daily period of six hours. The full erection train consists of three sections: the auger-borer unit, the mast-planting unit, and the concrete-mixing unit.

The Auger Borer Train is hauled by a locomotive and moves along the track stopping at predetermined points when the arm supporting the boring head is swung out over the site of the foundation to be excavated. The Auger Boring Machine can drill cylindrical holes up to 13 ft. deep and of varying diameter, 2 ft., 2 ft. 9 in., and 3 ft. 6 in. The Boring head is changed to suit the particular type of foundation required and to suit the ground conditions, for instance, a hole up to 3 ft. 6 in. diameter can be drilled through a light sandstone strata by using a suitable boring head. It can swing out up to 13 ft. 6 in. from edge of track, and the whole machine has a forward and backward movement on its chassis of 4 ft. This eliminates the necessity for moving the whole train when finally locating the boring head above the mast position. The boring operation normally takes less than two minutes. A tarpaulin apron is spread out from the borer vehicle so that any spoil thrown up by the boring head does not fall on to the ballast.

Steelwork planting is done by the second unit which is self-propelled, and consists of a mobile diesel-electric crane marshalled between two flat waggons loaded with steel masts. As it stops near each foundation excavated by the auger-borer unit the crane lifts a mast from a waggon and lowers it into the hole. The mast is then clamped at the correct angle by a steel frame which sits on the top of the hole. Arrangements are made so that this section of the train can be supplied with further loaded waggons of steel masts in the course of its work.

A water tender, a generator waggon, the continuous concrete-mixing unit, two 50-ton hopper waggons, and a brake-van make up the concrete-mixing unit which has its own locomotive. The water tender, specially rust-proofed inside, carries water which is piped to the mixer vehicle. The generator waggon contains a diesel-powered generator supplying electricity to various electric motors in the train, an air compressor, and a water pump. The concrete-mixer itself is contained in a special covered bogie vehicle which has two receiving hoppers, one for sand, and one for aggregate, and a silo with a capacity for 12 tons of cement. The sand and aggregate hoppers are filled by means of the conveyor-belt system which runs through both hopper waggons into the mixer vehicle. All the ingredients can then be fed continuously and in the correct quantities into a screw feed which mixes the concrete. In operation, the mixing unit is halted beside a mast position and concrete is poured from the movable spout into the foundation hole. The steel former holding the mast in position in the hole is not removed until the concrete has set.

The new mixing unit, providing a continuous supply of concrete, will assist in speeding up the mast-planting stage of electrification work. Hitherto the works train has used a rail-mounted mixing unit of conventional design to which the ingredients were moved from adjacent waggons by wheelbarrows. This former concrete unit will continue to be used in complicated junction areas and sidings where speed is not so essential.



Testing the concrete-mixing unit.

NEW EXPLANATION OF SUNSPOTS

Sunspots are "islands of intense calm floating in the otherwise turbulent sea of the Sun's atmosphere". This thesis was advanced by Dr Donald H. Menzel, director of the Harvard College Observatory, in the annual report of the Smithsonian Institution. It is quite the opposite from the concept widely held in the past that these small, dark regions on the Sun's face indicated solar storms or the vortices of solar cyclones.

The "islands of calm" thesis has become possible only with the most recent advances in solar astronomy and especially through knowledge of the Sun's magnetic fields. The explanation of these curious spots, which vary in abundance through an eleven-year cycle and have been credited with all sorts of effects on terrestrial phenomena, is due to "the relatively new science of magneto-hydrodynamics which casts new light on the nature of highly ionised gases in the presence of a magnetic field".

Dr Menzel explains: "A gas so hot that the electrons have been torn from most of its component atoms is highly conductive to electricity. The magnetic fields associated with any electric currents that may be present impart to the gas a certain amount of rigidity, as if the material were semi-solid. . . . The atoms can flow up and down, to a certain extent, parallel to the lines of force. But we cannot expect the violent turbulence associated with strong convection."

There remain many unsolved problems associated with the Sun's outer atmosphere, Dr Menzel points out in this report. For example, the shining surface of the Sun, the part unaffected by sunspots, is by no means uniformly bright. It contains many bright flecks on a slightly darker background. These generally are called "granules". They are about 300 miles across, on the average, but with much variation in size. In the neighbourhood of sunspots they are much coarser. Near the edge of the Sun there are large, darkened patches with veined structures, generally referred to as faculae.

An early theory was that the granules were clouds of some solid material, floating in the gaseous atmosphere and appearing more luminous because of their higher light emission, like a gas mantle heated to incandescence. This thesis was abandoned, Dr Menzel says, because the solar temperature is too high to permit either liquid or solid matter. The granules can be explained, he points out, as follows: "The turbulent convection (in the Sun's atmosphere) serves to bring the hotter layers closer to the surface."

"We are now in a position", he says, "to understand the darkness of the sunspot relative to the surrounding photosphere (the visible surface of the Sun's atmosphere). In a region where magnetism has not inhibited convection, the outer layers are hotter than they would be otherwise. They are, consequently, more luminous than the spots, where convection does not occur. In the region immediately surrounding the spots, the convective layer must rise higher. . . ."

Curious conditions would result if the whole surface of the Sun were one big sunspot—that is, "if a magnetic field strong enough to inhibit convection through the entire solar atmosphere should suddenly come into existence. The temperature of the photospheric layer of the Sun would cool by at least 2000 degrees, to a value approximating that of a sunspot. The total amount of energy radiated, . . . would decline to about 20% of the present value", but the same amount of heat would be produced in the Sun's interior. It requires about 50 million years for this heat to get from the core to the surface. Radiation would accumulate in the interior. This would cause the Sun to swell until, in some tens of millions of years, the increased surface area would compensate for the lower radiation into space.

GRANT PATENTS MORE FREELY

The recent appointment of a non-scientist to be the new Controller-General of Patents high-lights one of the incidental problems which have arisen from the growth of research and development in recent years. The number of applications for patents has for some time exceeded the number granted and the backlog is now more than 30,000. Recruitment of the staff needed to cope with these arrears and with the current rate of applications has proved impossible in spite of the considerable efforts which have been made to attract scientists. The work of patent examining is not everyone's cup of tea. Nowadays there is a strong general demand for scientists and few are attracted by the blend of scientific and legal problems which the Patent Office offers. There was no difficulty in recruiting staff during the period between the two wars, as there was then a shortage of jobs for scientists.

There is, however, no likelihood of any decrease in the rate at which patents are applied for; industry is unlikely to become less patent-minded; in fact, while industry continues to expand its research and development programmes, it will have more and more inventions to patent. The solution to these problems is not easy to foresee. The rate of output of the present staff of examiners is already as great as is compatible with the present very high standard of care with which each application is vetted. This involves analysis of the claim and its comparison with existing patents and with normal practice; often it involves correspondence with the inventor or his agent and an effort to agree on an acceptable specification; meetings may be required.

One possibility should be to relax this standard so that the examination became more of a go/no-go affair, and a staff of the existing size could get through the work faster. Since a proportion of the resulting specifications would be less well drawn, and less closely scrutinised for novelty, they would become more vulnerable in the Courts which, accordingly, would have more work to do in adjudicating on them. The overall result of such a relaxation of standards would be to lay the onus of drafting firmly on the patentee, to whom as the beneficiary of the patent it really belongs. The burden of adjudicating on novelty would fall more fully on the Courts, where it is bound to end up in any case. The closest scrutiny would then only be accorded to those patents which warranted it because they were opposed.

All this might not be a bad thing, but to introduce this or any other major change would involve the analysis and balancing of many considerations including the wishes of industry and the intentions of Parliament. It can, however, only do harm if these problems are not tackled soon, if the backlog of applications is left to grow, and if the time for dealing with them continues to lengthen.

THE HYDRAULIC SCALE MODEL

P. DANEL

Directeur Général, SOGREAH, Grenoble

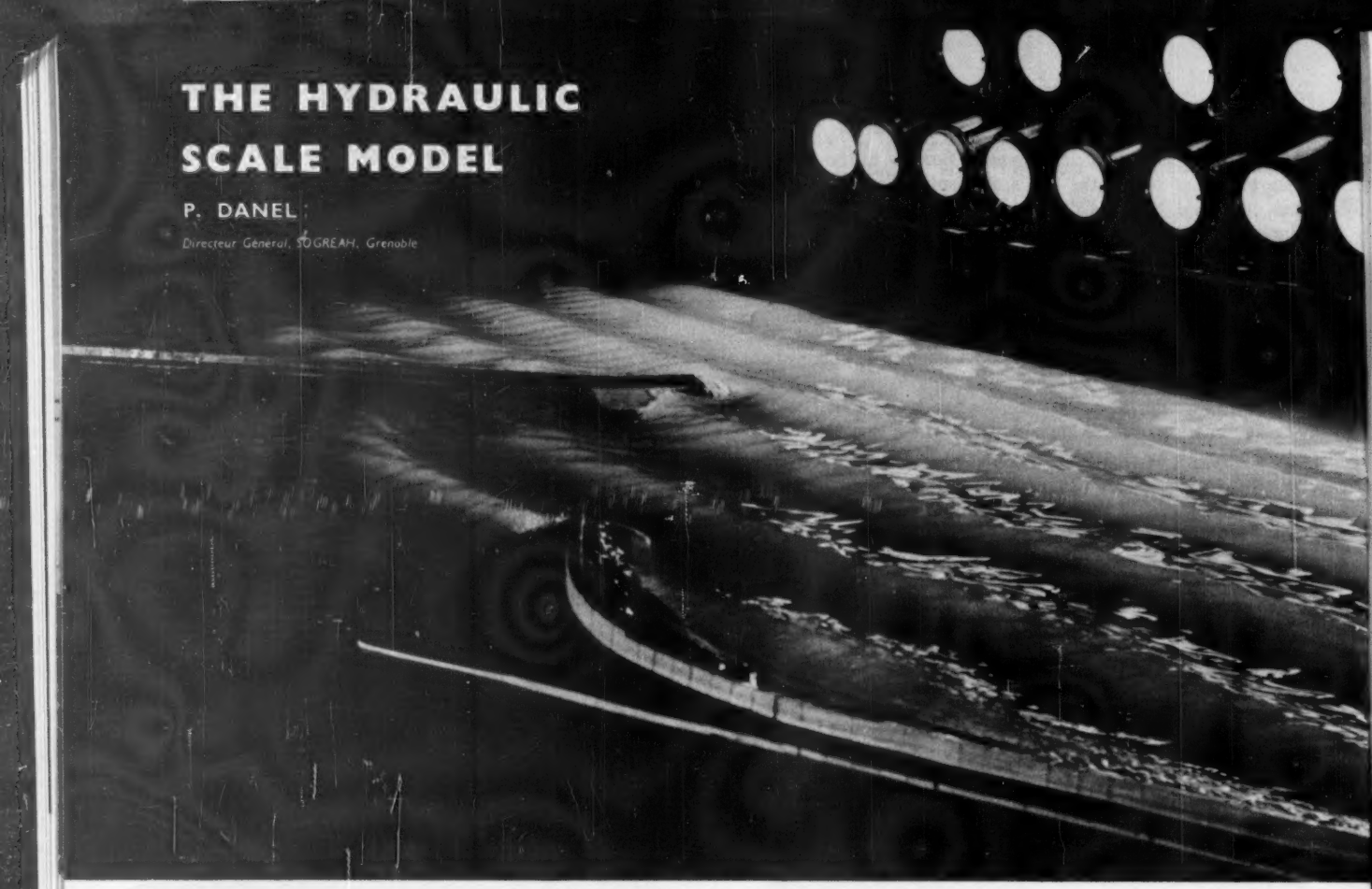


FIG. 1. Mers-el-Kébir (Algeria). Effects of swell on the model.

When a visitor enters the Experimental Station of SOGREAH (Société Grenobloise d'Etudes et d'Applications Hydrauliques) a strange new world is revealed to him. The laboratory is a technical Lilliput. It represents everything that exists in the world of hydraulic installations, from gigantic dams to enormous ports, including tortuous streams and the vast estuaries of great rivers, all in miniature, all in the form of models re-creating the actual conditions of nature.

What is a scale model? Essentially it is the means of reproducing, on a small scale, the natural phenomena whose behaviour and effects are to be studied, and also the works designed to protect man against these phenomena, or to help him make use of their resources.

Thus, if Rhodesia wants to construct a dam on the Zambezi, or if Argentina decides to install a tidal power station, or Brazil a naval base, or if France has to protect the inhabitants of the Arc district against the devastating floods of the river, it is to the scale model that one turns to solve the problem. As an extension of theoretical hydrodynamics, experimental hydraulics, with the scale model, allows one to bring into play every parameter, whatever its complexity and interaction, and to arrive at the solution empirically. The scale model is also an excellent instrument of forecasting.

But the analogy principle involves more than simple reduction. Sometimes distortions are necessary to allow for those properties such as density and viscosity which, in the nature of things, cannot be properly scaled down. Thus, at first sight, a model may appear to us a false representation of its counterpart in nature; the scales of height and surface may be completely different, for example. Once conceived and constructed, however, the model is adjusted, and its precision will depend upon that of observations made from Nature. Topography, geology, hydrology, climatology, the measurement of flow, the physics of waves, the study of matter carried by water, for all these the hydraulic engineer, often working in close collaboration with public or private specialist organisations, will require the services of a great number of scientific techniques. If the problem studied concerns flotation phenomena, a particularly difficult stage in the adjustment is the choice of mobile matter to be used in the model. This material might be sand, sawdust, or plastic granules of varying sizes.

At the same time one must work out an arrangement for reproducing the phenomena which are to be studied on the model. This sometimes means improvising or combining the movements of different devices. An example may be seen in the complex and accurate machines which, by a technique of self-regulation, automatically control the motions of tides, reliably regulating the amplitude and frequency as desired. Thus, wave-machines will whip up a swell to be measured by recording instruments, pressure-gauges will measure pressure, flow-meter currents, limnigraphs will indicate levels, miniature ultrasonic sounding apparatus will record the variation of the bottom, and pumping machines will distribute water according to the flow requirements of the experiments.

And now begins the really big adventure. The scale model begins to live its own life before the eyes of the engineer. Waves break over a jetty whose resistance is being studied, a jet gushes out from the orifice of a dam, a river takes possession of its bed, a miniature tide actuates turbines representing a tidal power-station, or gently displaces sandbanks in an estuary. And often the engineer has only to move his hand for his dam to tremble under the eddies of a flood, or the breakwaters of his miniature harbour to disappear under the waves of a storm. According to how the phenomena develop, he will then be in a position to study every useful solution, halting the process at will to try out such-and-such a remedy, introducing such-and-such a modification; in short, to play technically with the model. It has, in the end, become a real computing machine.

DIFFERENT ASPECTS OF HYDRAULICS

Aided by scale models, the Beauvert Hydraulics Centre is today able to study all problems relating to the hydraulics of rivers and streams, of seas and oceans, the conveyance of material by pipe-line, and the hydraulic decanting and sorting of materials.

In the study of rivers and streams the centre has been able to give particular attention to the installation and equipment of large hydroelectric plants as well as the control of river courses. The research undertaken for the dams of Salto Grande and Barra-Bonita in Brazil, Sarpsfoss in Norway, Bin-el-Ouidane in Morocco, Le Marinel in the Belgian Congo, Bhakra in India, Eye Brook in England, Canon del Pato in Peru, Bersimis in Canada, Djatiluhur in Indonesia, Kariba in Southern Rhodesia, Narragamba in Australia, the great French projects which include Génissiat, Donzère-Mondragon, Castet and its underwater installations, Tignes, Serre-Ponçon, also the schemes for the Rhône Valley as well as those for the valleys of the Durance, the Isère and the Drac, and in the Far East the hydrological and geological study of hydroelectric plant on the Da Nhim in Viet-Nam have all been based on study conducted at the Beauvert Hydraulic Centre.

The hydraulics of seas and oceans includes all research concerning the equipment and protection of ports, such as those of Heligoland in Germany, Portland in Australia, the naval base at Aratu, Macau and Recife in Brazil, Arica in Chile, Benin in Dahomey, the Kent northern sea-wall in Great Britain, Benghazi in Libya, Funchal in Madeira, Ensenada in Mexico, Zonguldak in Turkey, and many others in Syria, the Netherlands, and New Zealand, to mention only a few.

Research connected with the protection of ports has led

FIG. 2. Scale model of the Nile and the Sad-el-Aali Dam (Egypt).

FIG. 3. (*Left*) A row of tetrapods before being placed in position along a jetty wall.

FIG. 4. (*Below, left*) The tetrapod, developed in the course of the hydraulic study of rivers and oceans at SOGREAH, has proved far more efficient in the protection of ports than the rectangular type of concrete block previously used.

FIG. 5. (*Below, right*) Model of the port of Mers-el-Kébir (Algeria).

particularly to the invention of new blocks, known as tetrapods, which completely revolutionise the conception of artificial blocks. This invention is manufactured by the Société Sotramer, which today has undertaken work in about fifteen different countries. Among their most recent schemes we may note the placing of 625 tetrapods at Wick in Scotland, and 3000 tetrapods of between 10 and 16 tons at Veracruz in Mexico. Ports now protected in this way include those of Wellington in New Zealand, Crescent City in the United States of America, Leixões in Portugal, Valletta in Malta, and Wick and Whalsan in Great Britain.

Moreover, the Maritime Hydraulics Service studies the problems of navigation in river estuaries and canals, such as Suez where the latest research on the possibility of passage for super-tankers carrying oil was undertaken on behalf of the Shell Company.

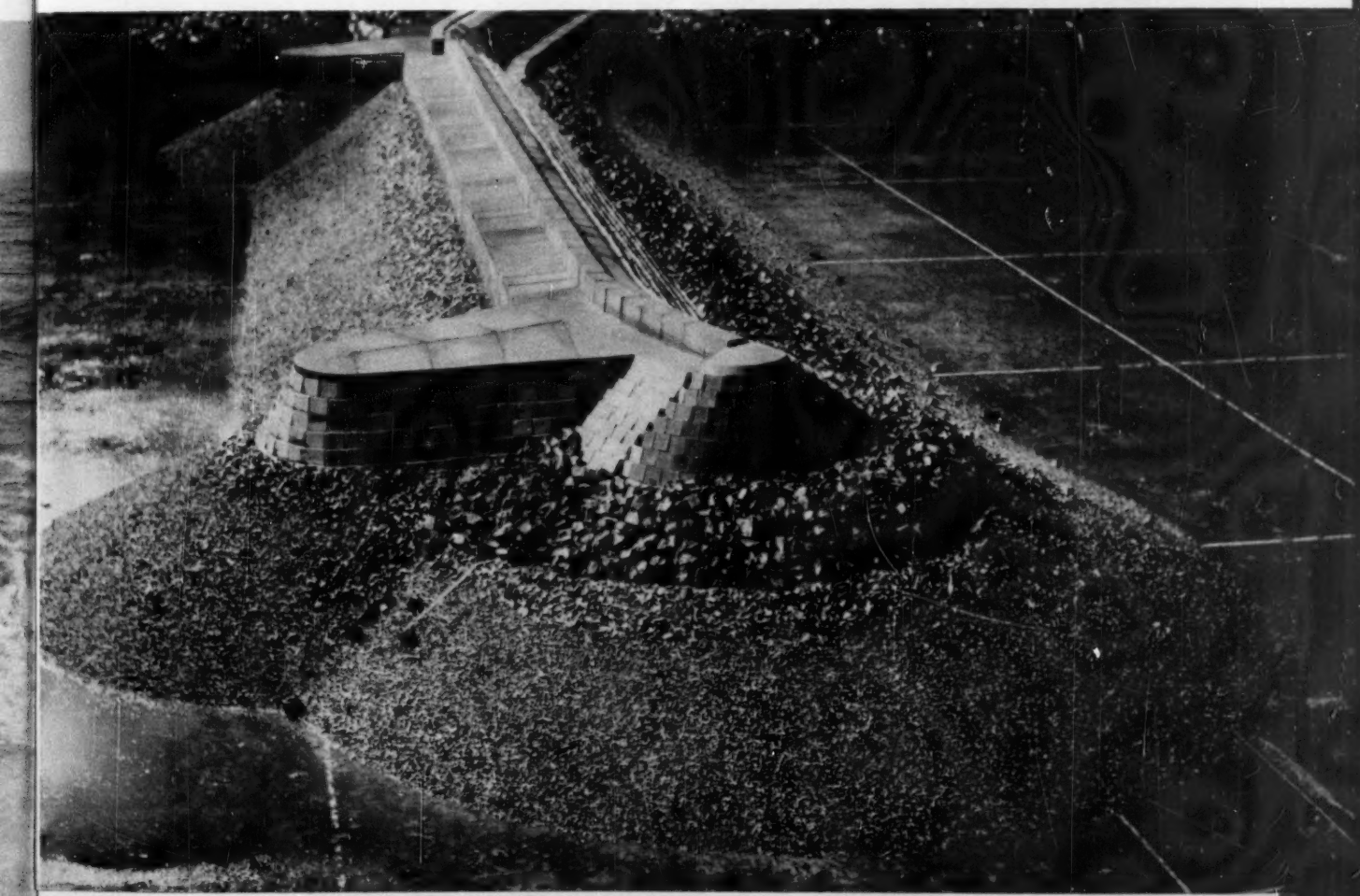
Finally, maritime hydraulics is also concerned with the use of tidal power and the building of the revolutionary tidal power-stations in France (those of the Chausey Islands, and at the estuary of the River Rance, the latter being the first project of this kind in the world) and in the Argentine (the future tidal power-station of 600,000 kW which is to be built on the Atlantic Ocean, in the isthmus of the Valdés Peninsula, between the Bay of San José and the Golfo Nuevo).

The conveyance of material by pipe-line, and in particular the hydraulic handling of coal, is one of the many other research projects being studied. The hydraulic decanting and sorting of materials has led to the development of the "Lavodune", the principle of which, first discovered from the sorting properties of correctly placed dunes, was recently applied with success to the sorting of diamonds

OTHER FLUID RESEARCH

However, it is not only "water-users" who set problems for the hydraulic engineers; subjects often far removed from classic hydraulics become the object of research at Beauvert. SOGREAH once studied the mixing of air and water which takes place in the white foam of waterfalls; this research having been noticed by some metallurgists, the laboratory was then asked to study the mixing of air and molten iron, which takes place in Thomas converters during the transformation of iron into steel. The production of steel from a converter is in fact proportionate to the amount of air (occasionally oxygen) which can be blown through it. But if a certain air pressure is exceeded, a violent and dangerous projection of molten steel takes place. Following advice based on experiments by the laboratory, the bottom of the steel-converters was modified and the capacity of some of them has now risen from 50 to 70 tons. This success brought in other requests whose object was still further removed from hydraulics, though still dealing with the mechanics of fluids. In this way SOGREAH came to study flames in metallurgy. This piece of research was undertaken without flames but, still according to the analogy principle, by blowing warm air into cold air.

Finally, of course, experimental hydraulics came to be applied to atomic research. And today the scale model can be used to study the exchange of heat, the hydraulic flow in atomic piles, and the mechanics of liquids and gases and the separation of isotopes.



SHORT HISTORY OF A RIVER

The scale model thus shows itself to be an instrument of almost universal scope, whose value becomes daily more important to the research worker. A sensational confirmation of its possibilities is given by the conclusion of some research work undertaken for the Seine Estuary in France.

The seaport of Rouen owes its existence to the Seine. It is the river which brings it richness and life. It is the river which, if closed to shipping, would halt the growth of the town and bring about its death. So, for centuries, men have fought at great cost against the sand which is rolled and carried up by the Channel swell, tides, storms, and even the currents of the river itself, trying endlessly, by means of dredging and other major operations, to determine the position of the sandbanks and the navigable channel.

Faced with considerable expense every year, the Department of Civil Engineering of Seine-Maritime and the Rouen Chamber of Commerce asked SOGREAH to put the problem of the Seine Estuary to the test of the scale model. The problem proved difficult to solve. However, the technical experts had at their disposal some unique documentary evidence: for nearly two hundred years observers had recorded the entire history of the Seine Estuary, noting particularly the successive aspects of the sandbanks and the river bed. Thanks to this considerable store of information, and after days and nights of incessant work, the model was at last developed and adjusted.

Launched on its own, and working with its own momentum, the model reproduced in miniature, but with remarkable fidelity, the history of natural phenomena in the Seine Estuary from the year 1869. More than eighty years in life of the river were unfolded with precision before the eyes of the engineers, making it at last possible for them to forecast the real aspects of the river bed for the next fifty years, and to give a clear idea of the work required. All this was done with a degree of certainty which was remarkable, considering the size and complexity of the phenomena involved.

The Beauvert Hydraulics Centre developed from the Dauphiné Hydraulics of Etablissements Neypric in Grenoble. From the very beginning this firm wished to make its workshops the centre of inspiration for the study of hydraulic problems, and worked in close co-operation with a number of other organisations, particularly the University of Grenoble. In order to permit research into the fundamental data necessary for the construction of turbines, an artificial waterfall and an experimental laboratory of scale models were created inside the factory itself, and this led to the development of the Dauphiné Hydraulics Laboratory.

Having proved the value and efficiency of experiments based on the analogy principle in the case of machines, the Dauphiné Laboratory turned its attention quite naturally to other aspects of hydraulic research. With the ever-increasing expansion of the experimental station the Société Grenobloise d'Etudes et d'Applications Hydrauliques came into being at the Beauvert Hydraulics Centre. Today SOGREAH has about 15 acres of laboratories and scale models, and employs 500 engineers and technicians.

FIG. 6. Scale model of the Seine Estuary. Study of the behaviour of the sandbanks.

ENGLISH AS THE LANGUAGE OF SCIENCE

ALISON MEGROZ, B.A.

"And as for exotic words and terms borrowed from other languages . . . I hope you will find that I have not at all affected them, but have rather studiously declined the use of these, which custom has not rendered familiar, unless it be to avoid the frequent and unwelcome repetition of the same word . . . or for some peculiar significancy of some such word, whose energy cannot be well expressed in our language, at least without a tedious circumlocution."

Though Sir Robert Boyle wrote these words in the 17th century, they could apply equally well to the 20th. In some ways the situation in 17th-century England was similar to that of today. Latin had been abandoned as the language of the learned and the vernacular was taking its place; it was an age of scientific investigation and discovery. Today the classics are no longer the backbone of English education and more and more words are needed as science pushes on with its discoveries and inventions.

NEW WORDS

Many vivid words and expressions are being taken from everyday English and given specialised meanings, and words are being formed in new ways.

In electronics there are expressions like a "long-tailed pair" and a "flip-flop" circuit. The flip-flop circuit, which I first heard referred to by a Frenchman as "le fleep-flop" (it can easily be adapted by the speakers of foreign tongues), must have originated about 1934, for in a book entitled *Wireless*, published in the Home University Library series in 1933, Eccles, the originator of the circuit, describes the Eccles-Jordan circuit patented in 1918. One sees the aptness of the as yet unborn term in his description; if it had been in existence he would surely have used it: "The chemical see-saw of the closed pendulum circuit makes one anode rise while the other falls in potential." Two years later, in Hutchinson's *Technical and Scientific Dictionary of 1935*, the flip-flop oscillator is described as "an arrangement of valves so that only one is conducting at the same time".

In chemistry the Americans have contributed the lively name of "cat-cracking" to the splitting up of the larger molecules in oil with the aid of a catalyst. While oil-cracking, like atom-smashing, is a forceful term, the vigour of "cat-cracking" is due to a false transference of meaning: the layman sees a cat before he thinks of the word catalyst. This is typical of a certain group of Americanisms, for example, "souping up" from "supercharging".

Other examples of borrowings from everyday English which help to describe scientific events are to be found in metallurgy, which uses such terms as "lattice" to describe crystal formation and "jog" for a certain type of irregular crystal, as well as the familiar "metal fatigue", which became known to a wide public after the Comet disasters. An equally vivid, though less known, term is "creep": the deformation of metals under a steady load.

Metal fatigue, according to the Penguin *Dictionary of Science*, means deterioration of metals owing to repeated stresses above a certain critical value. "Critical" is an example of an earlier borrowing from the ordinary language. Eighteen forty-one is the date given by the *Shorter Oxford Dictionary* for the first appearance of its specialised meaning in physics and mathematics: "constituting or relating to a point at which some action, property or condition passes over into another; constituting an extreme or limiting case." When classical physics was about to push ahead it borrowed many such words from English and invested them with special meaning. Other examples are "power", "force", "energy", "work".

ATOMIC SCIENCE

From critical as it is used in nuclear-reactor technology comes a new noun, "crit". Here critical means capable of maintaining a chain reaction at a constant level, and crit is the mass of fissionable material which, under a given set of circumstances, is critical.

Atomic science is the key science of our age and it has brought with it many new words formed in various ways. The words borrowed from Greek are short, easy to pronounce and spell, and most of them end with the Greek neuter noun ending "on". So the atom was found to consist of protons and neutrons and electrons, and now the positron and many others have been added to the list. The words are manageable. Their disadvantage lies in their lack of individuality, for the mind has to make special efforts not to confuse them. It is not only the components of the atom that are named in this way: the machines used to accelerate electrons to high energies are the betatron and the more powerful synchrotron which combines features of the betatron with that of another apparatus, the cyclotron, and the Bevatron and the Cosmotron are proton synchrotrons. One begins to long for a word that will not end in "on", particularly in the not too beautiful "tron".

In the description of the cyclotron one can watch the coining of a word, for the charged particles which receive energy pass between two semicircular electrodes known as "dees":

Atomic science has its share of borrowings from the everyday language: "pile", "core", "clean" and "dirty" bombs, "heavy" water.

INITIALS AS NEW WORDS

In the naming of its machines it has used initials to form words. Like the war-time word "Pluto" for *P*ipeline *u*nder *t*he *O*cean, atomic reactors have been given names coined more or less exactly from the initials of words that explain them. Nero is a low-energy reactor at Harwell, and it derives its name from Na (sodium) Experimental Reactor O (low energy). On this basis both Dido and Bepo are recognisable to the initiated as low-energy reactors. Dido from DDO, the chemical symbol for heavy water, used to moderate neutrons and carry away heat; Hermes, the heavy-element isotope separator, and Zephyr, the first low-energy fast reactor, are examples of inexact coinings of words from initials.

The latest arrival at Harwell is Zeta (Zero Energy Thermonuclear Apparatus), whose existence was revealed

in the Atomic Energy Authority's annual report in August of last year. There are many electronic machines named in this way, such as LEO (Lyons Electronic Office); CROWD (Central Recording of Works Data), a machine which records the operation of machinery and produces a condensed record for analysis; and ENA—how appropriate!—(the Exeter Nursing Aid), a mechanism which lifts patients.

One of the most familiar of these machines is Ernie, who has taken up his abode at Lytham St Anne's. Many more people know him than could say what his initials stand for: Electronic Random Number Indicator Equipment. When Ernie is visualised it is not as a piece of equipment but as a robot or mechanical man, so much so that *The Observer* of May 26, 1957, spoke of him almost human. "The heart of Ernie", it said, "is a glass tube filled with neon gas."

From the First World War onwards, words with no previous meaning have been condensed from initials, ANZAC being one of the earliest. After the Second World War there were many new ones, such as UNO, with its continental variant ONU, UNESCO, NATO, etc. In the 1930's, science introduced one of these which has become a word in its own right and which is one of the few that will last: Radar (*Ra*dio *D*etection *a*nd *R*anging). A recent scientific new-comer is IGY, the International Geophysical Year, with its French counterpart AGI, Année Géophysique Internationale.

One piece of apparatus to be used during IGY is what *The Times* of May 24, 1957, called: "that appealing hybrid", the rockoon: a combination of rocket and balloon in which the balloon is to launch a comparatively small rocket at an altitude above the main mass of the atmosphere. No official name has been given to this rockoon but it has been suggested that the name "Harpy", which is written on its "nose", is a nickname based on the initials of High Altitude Research Project. Rockoon is a hybrid word made from rocket and balloon, like smog from smoke and fog. A similar word is elevon, a combination of elevator and aileron. "Snark", an American inter-continental guided missile, has elevons.

Initial letters are not only used to form recognisable words like Pluto and pronounceable syllables like UNESCO, they are also used as initials: the BBC, the GPO, the USA and the USSR are examples taken from everyday life. Some scientific products are similarly named for brevity's sake: TNT for trinitrotoluene, DDT for dichloro-diphenyl-trichloro-ethane, PVC for poly-vinyl-chloride.

SCIENTIFIC TRADE NAMES

Science has given the 20th century many commercial products, and this has led to the formation of new words, some in ways already mentioned, others quite arbitrarily. From the English adjective "plastic", that which can be moulded, comes the generic term plastics. Thirty years passed before the name rayon was coined in 1924, giving the material it stood for the chance to exist in its own right and not be considered as an inferior imitation of silk. Nylon, like rayon, is an arbitrarily formed word with no etymological significance. It was the trade name used by E. I. Dupont in America, the firm which first produced it. Acrilon has been named by analogy with nylon but owes its origin to the acrylic acid used in its making. The British man-made fibre "terylene" is shorthand for *tere*phthalic acid and eth*ylene* glycol, as "polythene" is an abbreviation of polyethylene. Another proprietary name for a new material is ICI's Perspex, which has etymological significance since it comes from the Latin *perspicere*, to see through. Now that it has been treated so seriously as to be used for a piece of sculpture at last year's open-air exhibition of sculpture at Holland Park where its translucency was most effective, it may become as permanent an addition to our language as nylon or celluloid.

HOW TO MAKE NEW WORDS

Hundreds of thousands of new scientific words are being invented; hundreds of thousands more are needed. It is important that they shall be well chosen. Who wants to clutter up the language unnecessarily with words like "merostathmokinesis" or "spermiocalyptrotheca"? Compare two 19th-century words coined within twelve years of each other: "obdiplostemonous" (1800) and the attractive word "plankton" (1812). It would have taken more than the Kon-Tiki expedition or the adventures of Dr Alain Bombard to popularise a word like obdiplostemonous.

Popularisation is a dangerous word. It is just this that the scientist is afraid of: the distortion by popular usage of words that he has chosen to describe his findings, "word creep", in fact. In a technological age like ours, however, when the general public needs some knowledge of scientific developments and when scientists and technologists are so much in demand, the problem of communication is a serious one. As early as 1833 Michael Faraday had recognised this, for in that year, after completing his basic researches, he asked the Rev. William Whewell, Professor of Moral Philosophy at Cambridge, for appropriate words to describe his results. It was then that the words "anode" and "cathode", "anion" and "cation" made their first appearance. "Vitamin" is an example of a well-chosen word. It was coined in 1912 by a Pole, Dr Kasimir Funk, to replace "accessory food factors". It has meant not merely a saving of breath, of paper and ink, but also a saving of mental energy. It is easier for the mind to grasp "vitamin" than to work out the meaning contained in what Sir Robert Boyle might have called "that tedious circumlocution" accessory food factors.

The great need science has for words as an aid to thought can be seen in Prof. J. Z. Young's comprehensive survey, *The Life of Mammals*, which was published last year. He devotes a whole first chapter to the problem of a language that will unify the various biological sciences: botany, zoology, anatomy, physiology, biochemistry, biophysics, genetics, and so on. He finds a solution in borrowing the terminology of information theory, a branch of science based on modern methods of communication and particularly concerned with machines that control themselves. So living organisms remain alive by acting in a way that foreshadows the future: they make *predictions* based on *information* which is *coded* in their *memory systems* so as to provide a *representation* of the outside world. They have *control* mechanisms, what the engineers would call *feedback* mechanisms, to help them maintain a *steady state*. Prof. Young admits that this ingenious solution is

imperfect but he puts it forward as an aid to the unified study of man, animals, and plants. When it is no longer useful or stimulating it can be discarded.

Our age has seen a vast increase in the identification of minerals and metals, and as the quantity has increased the quality of their names has deteriorated. The seven principal metals known to the ancients were silver, gold, copper, lead, tin, mercury, and iron. Alexandrite, Albertite, Labradorite, Millerite, and Witherite are less inspiring. Proper names have been used to coin words with more effect in physics, where they have been used to denote electrical measurements: ohm, watt, volt ,and others. Some of the most attractive names for minerals are foreign importations like tungsten, which comes directly from the Swedish for hard stone, and the German words cobalt and quartz.

INTERNATIONAL WORDS

Because science traverses national boundaries, scientific words spill over from one language into another and there is a common stock of words which cannot be said to be the property of any one country or linguistic group. When element 102 is named (and it will probably be called nobelium after the Nobel Institute in Stockholm, where the work of isolating it was carried out), the name will conform to the international rules for the naming of elements, and it will be adopted by the scientists of all nations.

But if science is international, national feelings still run high and the question of which language, if any, shall be the language of science is not easily settled. That linguistic group whose language is chosen is obviously at an advantage since their scientists need not acquire or be forced to express themselves in a foreign tongue, while those countries which are now attaining nationhood resent a superimposed language and attach particular importance to the use of their mother tongue. In India and Ceylon, for example, there is a movement to replace English by a native idiom, though with this goes a fear of what may be lost and a desire that the trend should be gradual.

ADVANTAGES OF ENGLISH

Whether or not any action is taken to decide on a universal scientific language, it is obvious that for the moment, in spite of the growing number of Russian contributions to science and the vast populations of countries like China, English is, and is likely to continue to be, the most widely used scientific medium. Even in non-English-speaking countries like Sweden, scientific reviews are being published in English.

Linguistically it has qualities which fit it for such a role. It has the power to absorb words from many sources due to its mixed origins and its history first as the language of a frequently invaded island, then as that of an expanding power. Its disadvantages are its irrational spelling and the difficulty of pronunciation which this involves, and the psychological element already mentioned.

The alternative to a natural language is a constructed one. However, there is not one constructed language; there are many, each with their different advocates. Esperanto, Interlingua, and Basic English are the best known and have the greatest number of supporters, but Interlingua and Basic English, like natural languages, would be easier for some groups than others, and much of Basic would have to be unlearnt by the would-be speaker of English. And would the English-speaking scientist be required to restrict himself to Basic? Interlingua, which claims to be the common language of Europe, would put the speakers of European tongues at an advantage over others. In a recent UNESCO report on Scientific and Technical Translating and Other Aspects of the Language Problem, a strong plea for Esperanto was made by Dr Lapenna of Yugoslavia, who claimed that, as Esperanto would belong equally to all, it would be the exclusive property of none.

However, a constructed language can never be so flexible or afford so many means of expression as a real language and the pressure of internationalism is felt in other spheres besides that of science. The scientist who is forced to express himself or to read in another language than his own would probably prefer to acquire a language that would be a means of communication with another culture and people rather than an artificial tongue with a restricted use. Perhaps this acquired language could be considered not as an alien or superimposed idiom but as an adopted language. As Prof. Ludowyke of the University of Ceylon said in the same UNESCO report, "Most people will agree that in countries like India and Ceylon, English has to be regarded as an adopted language rather than as a foreign language on account of its extensive use for educational and other purposes."

TWENTY-FIVE YEARS AGO

THE SCIENTIST'S ROOM

The editorial columns of the May issue, 1933, comment on the Ideal Home Exhibition of that time contained:

> "on every hand [there] were fresh examples of 'science in the home'. Special interest was taken in the 'Rooms of the Scientists', which formed a remarkably complete 'bird's-eye view' of the progress of science, from the villa of Archimedes at Syracuse to the sphere of the balloon in which Prof. Piccard made his recent ascent into the stratosphere. Other scenes included Roger Bacon in prison, Lister's surgical ward at Glasgow Royal Infirmary, the tent in which Sir Ronald Ross experimented on the mosquito in relation to malaria, Darwin's study at Down House in which the 'Origin of Species' was written, Faraday's laboratory at the Royal Institution, and the cabin of the Marchese Marconi's yacht *Electra*. An interesting innovation at this year's exhibition was the demonstration of television in the fashion theatre, which naturally attracted much interest."

THE COELACANTH YIELDS ITS SECRETS

ETHELWYNN TREWAVAS, D.Sc.
British Museum (Natural History), London.

FIG. 1. The Coelacanth, *Latimeria chalumnae*, showing the foldable first dorsal fin, the second dorsal in the form of a fringed lobe, the broad tail with its fringing fin and its projecting middle portion, and the left, arm-like pectoral fin. The pelvic fins and the anal fin are hidden.

It is so long since DISCOVERY published news of the Coelacanths that some recapitulation is necessary.

In January 1939 Prof. J. L. B. Smith of South Africa, then a professional research chemist and a passionate amateur ichthyologist, announced the discovery of a living coelacanth fish. Fossil remains of the group had been found in rocks laid down 300 million years ago (Devonian) and in subsequent strata through the ages until in the relatively young rocks of the Upper Cretaceous (90 million years old) the group seemed to have become extinct. All man's digging in tertiary rocks, though it uncovered abundant fish remains, and all man's fishing in modern seas and fresh waters, had failed to disclose to science a single member of this group until December 1938.

DEATH OF "A LIVING FOSSIL"

At that time a fish which had been trawled off the mouth of the River Chalumna on the African coast of the Indian Ocean was saved from total destruction by Miss Courtenay-Latimer of the East London Museum, South Africa. Disappointingly, if understandably, all that had survived the taxidermist's treatment amounted to little more than a well-preserved fossil. Nevertheless, Prof. Smith was able to publish in 1939 a faithful and detailed account of what had been preserved, and established beyond a doubt that the fish (which he named *Latimeria chalumnae*) was a member of the Coelacanthini.

To Prof. Smith's unrelenting propaganda and his prompt and dramatic action we owe the preservation of the second specimen in December 1952 and the discovery that the headquarters of the surviving coelacanths lies at any rate near enough to the Comoro Islands for their capture by the fishermen of those isles to be not exceptional.

The story of the finding of the first and second coelacanths has been told by Prof. Smith in his own inimitable manner in his book "Old Four-Legs" (Longmans, Green and Co., 1956). Although its title is the nickname given to this anachronistic fish, with fins like legs, the book is even more interesting as the frank self-portrait of a dynamo of a man, who has recaptured in his maturity the fanatical enthusiasm of a young naturalist on whom the wonders of this planet are impinging meaningfully for the first time. Such an ever-youthful vision characterises many a scientist, but not many have the power or impulse to communicate it so frankly. The impulse in this case probably arose from the fact that in riding off so madly in all directions Prof. Smith inevitably collided with a few people who were pursuing exemplary and fairly predictable courses, and they seemed to think he should apologise. Instead, he has given us his unique *apologia*.

IMPORTANCE OF FULL DESCRIPTION

The ball now passes to the French, in whose territory the Comoros lie. An account of the third coelacanth was written for *The Times* by Prof. Millot, Director of the Institut de Recherche Scientifique de Madagascar. This was followed by a handsome memoir in which the external features were illustrated by photographs. Nine specimens of *Latimeria* now lie preserved in the laboratory in the Rue Buffon in Paris, some of them with their structure laid open in series of sections or dissections. From time to time, in tantalisingly small doses, we have been given an account of some critical structure, and a general description appears in the latest volume of the *Traité de Zoologie* (1958). Fuller details still await the labours of specialists.

The first description of the total anatomy of a coelacanth is a responsibility of which Prof. Millot and his collaborators are well aware. If interpretation is to go hand-in-hand with description a wide knowledge of the structure of living and fossil vertebrates must be brought into play because of the special relationships of the coelacanths with other groups.

Fig. 2 shows diagrammatically the lineages of the groups of fishes and the land vertebrates. We have only to notice how long the lines of evolution of man and *Latimeria* have been separated to realise that *Latimeria* is no missing link in the popular sense. The pedigrees of birds, reptiles, toads, when traced backward in time, converge with that of mammals including man long before they all meet that of the coelacanths. At the period when they must all have converged (Devonian epoch, over 300 million years ago) these ancestral forms were all fishes. There were no land vertebrates.

DESCENDANTS OF DEVONIAN VERTEBRATES

In Devonian times fish-like vertebrates with jaws were already represented by a number of diverse groups. Those which still have living descendants were:

1. Selachii (sharks), a still flourishing group.
2. Bradyodonti, surviving as rabbit-fishes (*Chimaera*, etc.), a dwindling group.
3. Dipnoi, fishes with a specialised crushing dentition, which kept a niche throughout the Mesozoic and are represented today by the lung-fishes in the fresh waters of the southern continents.
4. Rhipidistia, a group which did not itself persist long as fishes, but which gave rise to both coelacanths and land vertebrates.
5. Actinopterygii, surviving as the dominant bony fishes of today after having had a successful Mesozoic history too.

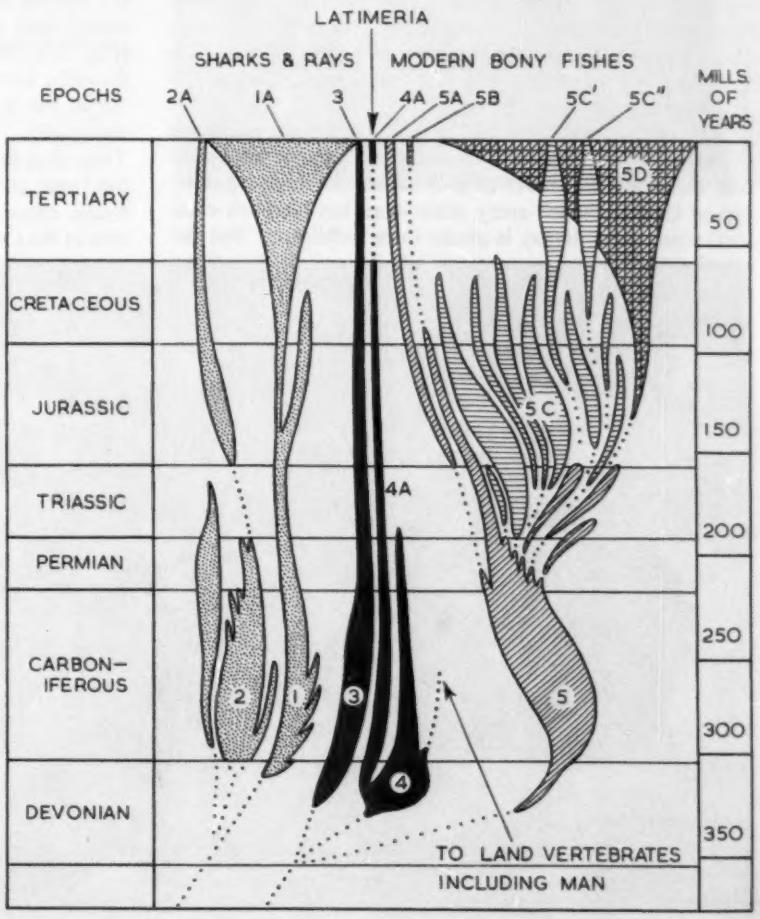


FIG. 2. Diagram of the history and relationships of the groups of fishes, based on an exhibit in the British Museum (Natural History). Groups 1 and 2 are cartilaginous fishes; groups 3 to 5 are bony fishes (Osteichthyes).

1. Selachii, persisting as modern sharks and rays (1*A*).
2. Bradyodonti, persisting as rabbit-fishes (Holocephali).
3. Dipnoi, surviving as lung-fishes.
4. Rhipidistia, giving rise to coelacanths (4*A*) and to all the land-vertebrates.
5. Actinopterygii, the ancestral group of which persists as sturgeons (5*A*), and *Polypterus* (5*B*); in the mesozoic it gave rise to Holostei (5*C*) with two families surviving in North America, and one branch of the Holostei flourishes today as the Teleostei.

Of these groups Nos. 3, 4, and 5, the bony fishes (Osteichthyes), show more evidence of relationship to each other than either does to Nos. 1 and 2. Nos. 3 and 4 are often grouped together.

The evolutionary fates of the two offshoots of the Rhipidistia are in complete contrast. Whereas the land vertebrates in their new medium branched out into the most diverse forms, soon leaving extinct the original clumsy amphibious colonisers of the land, the coelacanths have pursued an existence sufficiently uniform to allow them to retain a form varying within only very narrow limits. So, if the soft anatomy has kept the same degree of stability as the hard parts, we have in *Latimeria* a close approximation to the structure of its Devonian ancestor soon after it had diverged from the Rhipidistian ancestor of the land vertebrates.

DISTINGUISHING ADAPTIVE FROM ARCHAIC STRUCTURES

During their long history the coelacanths inhabited now fresh, now salt water in many parts of the globe, so that some adaptive changes must be expected on however stable a ground-plan.

Zoologists therefore look for the answers to such questions as: What is the structure of this only living member of a divergent vertebrate group? What details of structure may we consider to have been retained throughout its whole history? Which of these had it in common with the ancestors of the land vertebrates? What light do such characters throw on the inter-relationships of the five Devonian groups of fishes? Other questions, relating to the extinct groups, need not be considered here.

Students of fossil coelacanths and Rhipidistia await the revelations from Paris with a special excitement. They are like the would-be solver of a Ximenes crossword puzzle, one of those in which every other word has been left clueless, when the solution is about to be published. But the Ximenes of the fossil record has not been bound by the rules of fair play. However much intelligence and ingenuity may be employed there is no guarantee that a fossil puzzle is soluble, and only occasionally in the solution published. It was so in 1870, when the lung-fish *Neoceratodus* was discovered in Australia, with hard parts almost identical with those of the extinct *Ceratodus*. It was so in February of last year when Dr Lemche published in *Nature* an account of a superficially limpet-like survivor of a class of Mollusca believed extinct. The muscle impressions on the shells of the fossils suggested that it might be ancestral to the whole of the Mollusca, and it was therefore an event of special importance when in 1952 the Danish research ship *Galathea* dredged several specimens from a depth of 3590 m., west of the Isthmus of Panama. The first accounts show that this has the symmetry and some of the structural features characteristic of annelid worms, and thus supports the theory that worms were the immediate ancestors of Mollusca. So to our *Latimeria*, the solution of the coelacanth puzzle.

EXTERNAL APPEARANCE

A glance at Fig. 1 will remind the reader of the external appearance. The fish, 4–5 ft. long, has a big head and a moderately compressed body, ending in a laterally compressed tail prolonged into a short median lobe, the whole tail having a fringing fin. The paired fins are like short, scaled arms and legs, each ending in a rayed frog-man fin (Fig. 3); a little before the tail-fin there are an upper (dorsal) fin and a lower (anal) fin of the same type. Another median dorsal fin, attached in the middle of the back, is of the collapsible, fan-like type familiar in modern bony fishes. There is a pair of bony gular plates between the halves of the lower jaw. The scales are large and overlapping, with rough, tuberculate surfaces that are said to serve on occasion in the Comoros some of the uses of sandpaper.

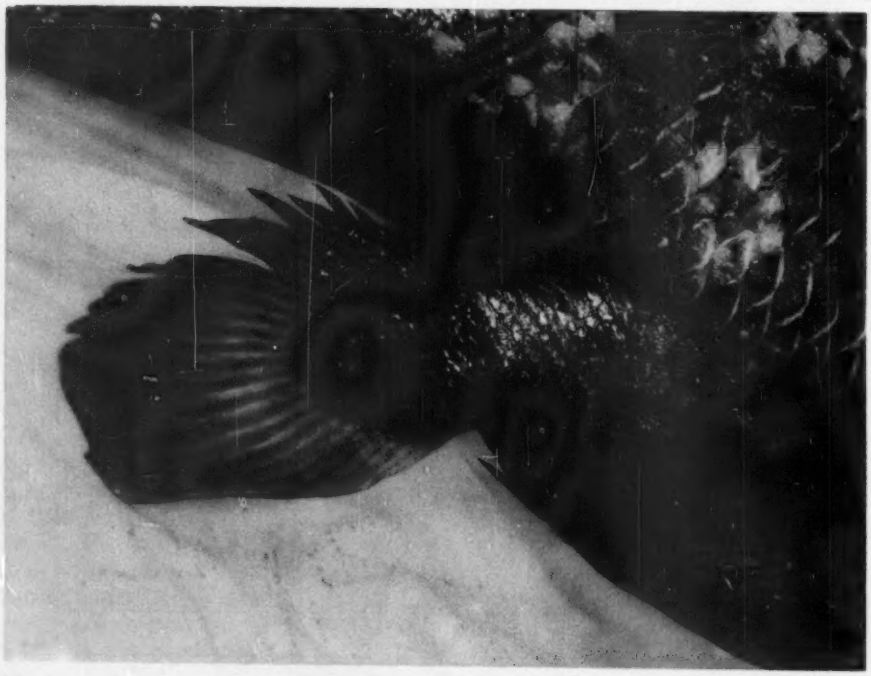


FIG. 3. *Latimeria*. One of the limb-like pelvic fins.

THE SCALES

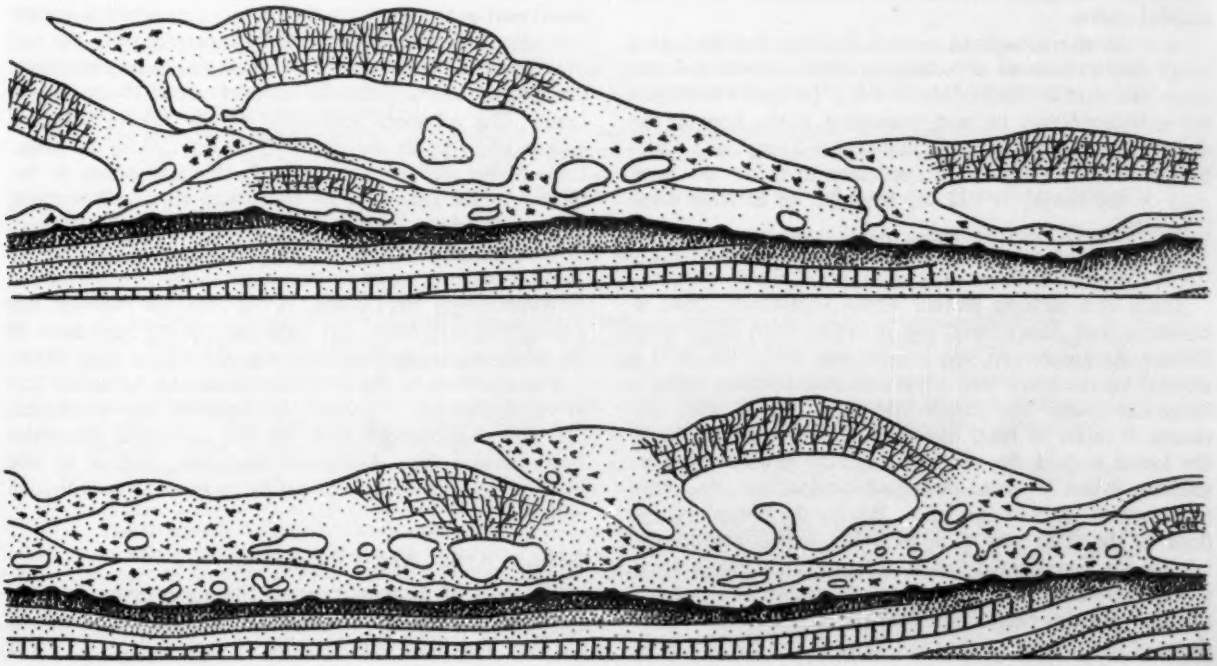
Fig. 4 shows the exposed parts of some of the scales. About three-quarters of the area of each scale is overlapped by three neighbouring scales, above, below, and in front; only the exposed hind quarter of the scales is tuberculate. Some of the desiccated scales of the first *Latimeria* were sectioned and described by G. H. Roux in 1942 (Fig. 5). The basis of each scale consists of thin layers of bone; this is overlain in the exposed part by a layer that looks like a number of piled-up and overlapping denticles resembling those that make a shark's skin so rough. Each of the denticles has a bony base, as shark denticles do. If Roux's interpretation of the scale is borne out by better preserved material, it seems that a *Latimeria* scale may be formed by the coming together of a layered bone and a number of dermal denticles with their basal plates, and may indicate the mode of origin of the so-called cosmoid scale that characterises the fossil Crossopterygii (Dipnoi, Rhipidistia, and Coelacanthini) as distinct from the early Actinopterygii, in which there is an addtional layer surrounding the whole scale.

AXIAL SUPPORT

The long axis of the body of all vertebrates is supported in the larval or embryonic stages by a rod composed of

FIG. 4. *Right: Latimeria.* The exposed surfaces of some of the scales.

FIG. 5. *Below:* Sections of parts of *Latimeria* scales. Upon the bony basal layers lie the denticle-like structures that form the tubercules of the exposed part of the scale. *(From drawings by G. H. Roux, 1942)*



cells turgid with gelatinous fluid, the whole bounded by sheaths of elastic fibres. If we imagine a sausage-shaped toy balloon drawn out very long and thin we have on a large scale something approaching the degree of rigidity and flexibility provided by this rod, the *notochord* or *chorda*. Above it lies the spinal cord or nerve-cord, in a membranous canal whose walls may be strengthened by a series of arches of cartilage or bone, each topped by a spine, the neural spine. (In coelacanths and some others these spines consist of a thin cylinder of bone and a core of cartilage. As the cartilage is not preserved in the fossils Louis Agassiz coined the name *Coelacanthus*, hollow spine, for the first fossils of the group to be described.)

In modern sharks the notochord is constricted and largely replaced by cylindrical or hour-glass-shaped vertebral centra of cartilage, which may be heavily calcified but never bony. In modern Actinopterygian fishes bony vertebral centra are present, but the early members of the group, and of the Dipnoi and Rhipidistia, had persistent notochords, only a few genera having ring-like bony centra. In the modern lung-fishes (Dipnoi) the main axis remains the notochord, although the neural arches, and their nether counterparts the haemal arches (protecting the main blood trunks of the back) are well developed. *Latimeria* resembles the early bony fishes and modern lung-fishes in having a persistent unconstricted notochord, even in the giant specimens of 4–5 ft. which are the only ones so far known.

At this size thin-walled, jelly-filled cells are not enough to maintain a rigid rod for the attachment of large body muscles. Prof. Millot and his collaborator Monsieur Anthony find that the elastic sheathing layers, enormously thickened and strengthened, form a tube containing a thin fluid, which only at the tail-end includes the torn and stretched remains of the cell-walls. The tapering end of the notochord extends into the small "supplementary caudal" fin. Here and there, quite irregularly, a few cartilage-cells invade the notochordal sheath from the adjacent neural and haemal arches.

In front, the notochord extends far into the head as a tough fibrous tube of considerable calibre (about 4–5 cm. outer diameter in a fish of about 4 ft.). In other vertebrates the notochord may be seen embedded in the floor of the skull in larva or embryo, but in no other living adult vertebrates does it extend as in *Latimeria* to below the front part of the brain. It did so, however, in at least some Rhipidistia.

THE CRANIUM

There is a striking feature which coelacanths have in common with Rhipidistia and in which both differ from Dipnoi, Actinopterygii, and sharks: the roof of the skull is divided in the adult into front and rear portions along a hinge-like joint. The fossils told very little of what this meant in terms of head dynamics, for opposite the hinge the lower part of the skull was usually incomplete. Presumably it had consisted mainly of cartilage, or some other tissue which left no fossil trace. Behind the hinge-level the floor of the skull had in it, in a few well-preserved and laboriously investigated fossils, a large cylindrical groove, partly surrounded by bone above and at the sides, and at the hind end also enclosed below to form a short tube. The shape of this groove was beautifully shown in 1932 by Prof. Stensiö of Stockholm in a Devonian coelacanth (*Diplocercides*) by the method of grinding a series of sections, photographing each one before it is ground off to expose the next. What could this groove have contained in the living fish? Prof. Stensiö's guess in 1932 was that it lay below the cranial part of the notochord and lodged a powerful muscle that worked the front and rear parts of the head about the hinge between them. In 1937 Prof. Romer of the U.S.A., working on a Devonian Rhipidistian (*Megalichthys*), surmised that a similar groove contained the cranial end of the notochord itself. And this he ingeniously deduced from the fact that the socket in the base of the front part of the skull was made of a coarsely fibrous bone of the same type as that at the back of the skull to which the notochord must have been bound. He wrote that the notochord must have been attached at the back of the skull and at the sphenoid socket and must have lain freely between these two points. It is exactly so that Millot and Anthony describe it in *Latimeria*, forming a powerful and supple union between the front and rear halves of the cranium. There is a pair of knobs on the hind face of the basisphenoid bone (Fig. 6, *bs*) which fit into a pair of sockets in the lateral parts of the bone named *suprachordal preoccipital* by Millot and Anthony (Fig. 6, *s*). Below these the front and rear parts of the cranium meet in a pair of smooth surfaces, held in place between grooves in the lateral wings of the cranium. Flanking the notochord below, a huge pair of muscles unites the two parts of the base of the skull, bulging into the palate. Movement at the hinge is restricted by fibrous bonds.

THE BRAIN

The fossils left us wondering how the brain could be accommodated in relation to the hinge. In *Latimeria* the brain is very small relatively to the size of the braincase, in which it lies cushioned on a pair of large blood-sinuses and embedded in fat, almost entirely behind the hinge. It is the facial part of the head, not the cranial part which is greatly developed. The pituitary is widely separated from the part of the roof of the pharynx which gave rise to its pharyngeal component, and a glandular cord of about 10 cm. unites them. The olfactory and optic nerves follow a curved course, allowing for movement of the head about the hinge.

As Millot and Anthony remark, this tiny brain, so unrelated to the braincase in shape and size, is a warning against drawing conclusions as to the brain-structure of fossils from cranial casts, at least in large fishes. It was not to be expected, however, that a giant fish would have a correspondingly large brain. A big pike, for example, has a miserable little brain, but little research has been done on the relation between brain and cranial cavity in large fishes.

The structure of the forebrain is said to be unlike that in Actinopterygii. Cerebral hemispheres are developed, but with membranous roof. In this *Latimeria* resembles *Neoceratodus* (the Australian lung-fish), but it is like *Protopterus* (the African lung-fish) in having an undivided optic lobe.

GILLS AND AIR-BLADDER

The gills of *Latimeria* are of the same type as in the Dipnoi, with a well-developed branchial septum separating the fore and hind hemibranchs of each gill-arch. There

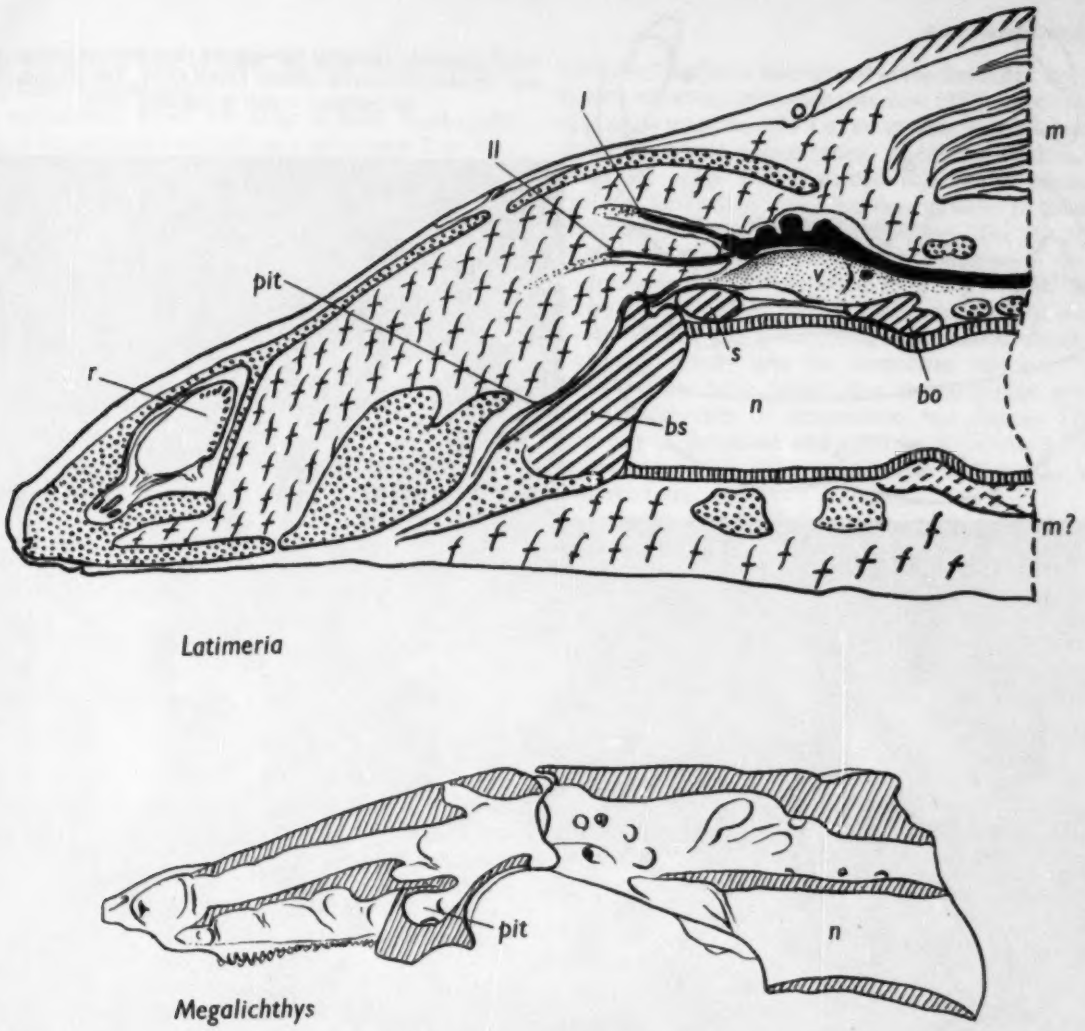


FIG. 6. Section of the head of a *Latimeria* showing the small brain (black), the large, fat-filled braincase, and the front end of the large notochord (*n*). Below, for comparison, is Prof. Romer's reconstruction of the right half of the braincase of the extinct (Permo-carboniferous) rhipidistian fish, *Megalichthys*. The actual length of the head of the *Latimeria* is about 1 ft.; that of the fossil braincase is under 4 in.

The upper figure is a diagrammatic interpretation of a colour photograph published by Millot and Anthony (1956). The lower edge of the figure is the roof of the mouth and pharynx, the upper the top of the head, behind which a piece of skin with obliquely set scales is cut through. The braincase and associated structures are cut through near the middle line. The braincase is mainly of cartilage (heavily dotted) but three bony elements (*bs*, *s* and *bo*) form part of its floor. Between *s* and *bo* the floor is membranous.

n is the fluid-filled cavity of the notochord, left white; the cut edges of its cylindrical fibrous sheath are shown by short vertical lines. It is attached in front to the oblique bone *bs*; and at the back of the skull is attached, slightly constricted, to the bone *bo*, which extends down at the sides and below to encircle it. (The interpretation of the structure labelled *m?* is doubtful.)

Fat and fat-impregnated fibrous tissues are shown by numerous *f*'s, but the bones are also impregnated with fat.

The hinge between front and rear parts of the skull is between the bones *bs* and *s* and is formed by a pair of ball-and-sinus (*v*) and surrounded above and at the sides by fat. In front of it the braincase is filled with almost pure fat, through which nerves and blood-vessels run. The nerves to nose (*I*) and eye (*II*) are seen leaving the brain. Just below the point where nerve II appears to leave the brain a bulge in the under-surface of the brain shows the position of the pituitary body, far behind the bony prominence which normally roofs it. The glandular cord of the pituitary (*pit*) descends steeply forward from this. In the *Megalichthys* skull, *pit* indicates the pituitary fossa.

The hinge between front and rear parts of the skull is between the bones *bs* and *s* and is formed by a pair of ball-and-socket joints out of the plane of the section. On the roof, its position is seen at the break in the cartilage.

In front is the rostral cavity containing the rostral sac (*r*).

The fat outside the braincase impregnates several kinds of tissue. The notochord is supported below, for example, by a transverse band of fibres under the two cartilages shown and attached to the sides of the floor of the skull. Above and to the right of the figure are the front ends of body-muscles, which must obviously be attached to strong fibrous tissue or bone in the occipital region, not clear in the photograph. The section is between the right and ieft infracranial muscles.

The covering bones of the skull, being mostly paired, are not shown, and neither are they included in the drawing from *Megalichthys*. In the latter the front third of the braincase is shown as cut to the right of the middle line, the rest through the middle, sagittal plane.

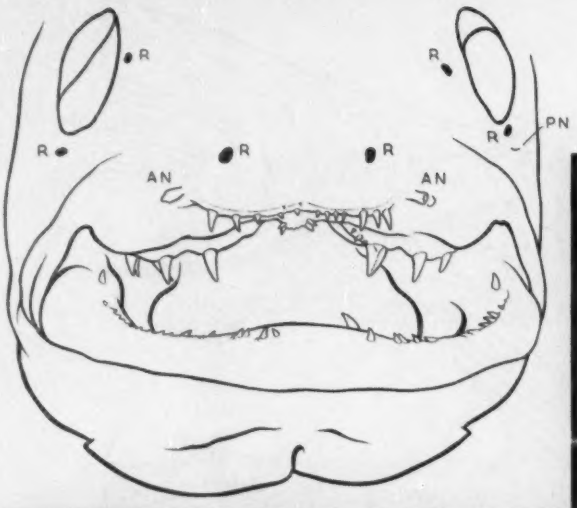


FIG. 7. Snout of *Latimeria* showing the three pairs of rostral openings (*R*) and the anterior, tubular nostril (*AN*). The position of the left posterior nostril is indicated (*PN*).

are five gill-arches, four of them, as well as the hyoid in front of them, bearing gills.

The air-bladder, which was large in some fossil coelacanths, is in *Latimeria* reduced to a tube some 2 or 3 in. long, prolonged to the end of the body-cavity as a filament surrounded by a thick bolster of fat, as in many deep-sea fishes (Jones and Marshall). Millot (1954) refers to this fatty vestige as a lung, not necessarily with any suggestion that it or its forerunner served as an air-breathing organ, but because, like the lungs of tetrapods, Dipnoi, and the fish *Polypterus*, it opens into the ventral side of the gut, not the dorsal, as do the air-bladders of modern Actinopterygii.

SENSE ORGANS OF THE SNOUT

A prerequisite to the colonisation of the land by vertebrates was the presence of a lung or lungs, and the land vertebrates show that efficiency in the use of lungs was increased by the provision of a separate air passage through the nose, between an external nostril and an internal, or choana. It has often been maintained that an approach is made to this condition in the modern lung-fishes, but in them the external nostril is on the lip and the internal not far behind it in the roof of the mouth, and a functional air passage to the lungs separate from the mouth is far from being established.

Palaeontologists have believed that in some of the Rhipidistia there is evidence of the existence of a choana. If they are right it too is near the front of the mouth, and the most that can be said is that it is a condition from which true choanae could be imagined to develop, though it is not at all certain that they did.

In coelacanths, however, no evidence of the choanate condition had been found and a report on the anatomy of the snout of *Latimeria* was eagerly awaited.

Prof. Smith's account of the snout of the first, imperfect *Latimeria* was very puzzling, to him as to his readers. No choana was there, but three outer openings on each side were reported as "narial openings". They led into a large median cavity in the snout. In addition Smith gave the name of "olfactory sacs" to a pair of independent sacs to which he could find no outlets.

Prof. Millot and Monsieur Anthony have confirmed the presence of the rostral cavity and its three pairs of openings, quite distinct from the olfactory organ. The latter is paired, each olfactory sac having two external openings, the anterior of which is at the end of a tubular papilla at the front of the snout; the posterior is a slit below the front of the eye. This arrangement is unlike that in sharks or lung-fishes, but is very much like that of Actinopterygian fishes so diverse as *Polypterus*, eels, *Channa* (*Ophicephalus*), and the spiny eel (*Mastacembelus*).

What the function of the median rostral organ may be is entirely conjectural. The cavity contains a rostral sac filled with gelatinous substance, and having sieve-like openings, one at the base of each rostral tube. Innervation is from the superior ophthalmic nerve.

Sharks and rays have on the snout, and sometimes elsewhere, a number of fine pores, each the opening of a tube which ends blindly in a swelling or ampulla. Tube and ampulla are jelly-filled and sensory nerves end in the ampulla. The function of these so-called "ampullae of Lorenzini" has been investigated in the thornback ray by the electric recording technique (Murray, 1957). The response of a single ampulla, tube and nerve-fibre was obtained in a delicately dissected preparation. Continuous pulses travel along the nerve and a sudden increase in mechanical pressure resulted in a like increase in basic frequency of discharge, followed by rapid adaptation. The stimuli producing this response are those which increase or decrease the pressure in the tube relative to that outside it. Thus a change in the general hydrostatic pressure of the medium would have no effect, but contact with a solid object when swimming would give an immediate response. Other experimenters have noted that the ampullae are sensitive to changes in temperature, but Murray believes that this is incidental and common to all such sensory systems and that the mechanoreceptor function is the important one.

The rostral organ of *Latimeria* invites comparison with the ampullae of Lorenzini rather than with any other known vertebrate organ, but its innervation remains to be worked out and it may be long indeed before experiments can be made on the living structure.

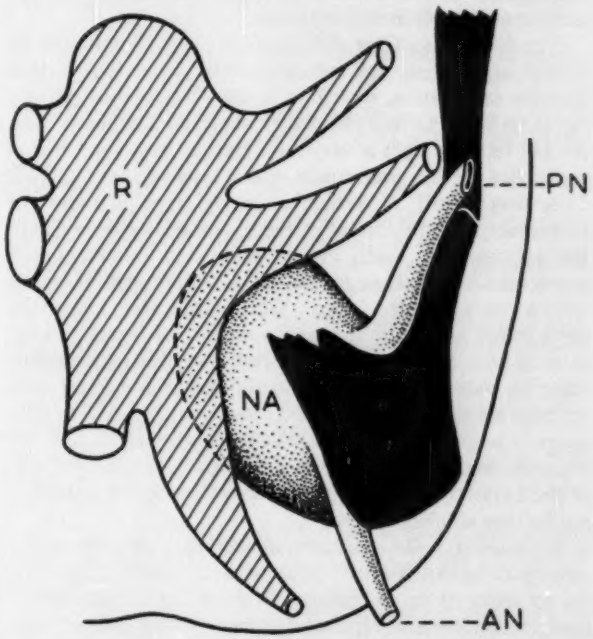


FIG. 8. The rostral sac (*R*) and the nasal sac with its anterior and posterior nostrils (*AN*, *PN*). Bones, partly cut away, are shown in black.

EYE

The eyes of vertebrates show an astonishing uniformity and there is even some convergent similarity between them and that of the octopus, an invertebrate. It was not expected, therefore, that the eye of *Latimeria* would tell us much about its relationships. It proves to be the typical eye of a crepuscular water animal.

The receptor elements in a typical retina are of two kinds: cones, which permit of sharp vision in good light, and rods, which are sensitive to the faintest light as such at the

expense of acuity. In *Latimeria* rods are abundant and cones extremely scarce.

A LIVING *LATIMERIA*

After dark on November 12, 1954, a fisherman of the Comoros dropped his baited, weighted line into 140 fathoms of water about 1000 m. off the shore of his island, Anjouan. At about 8 p.m. he hooked a big fish, which, on bringing to the surface, he recognised as a *Latimeria.* He decided to make a bid for the double reward offered for a living specimen, and, at the risk of losing all to the sharks, towed it in to the jetty. Then the officials took charge and carried out the plan that had been agreed upon. A whale-boat was submerged and *Latimeria* was transferred to it, covered with a net and so kept in a fairly roomy cage. All through the night it swam gently about, making no attempt to escape, a steel-blue fish with eyes shining yellow-green like a cat's. It swam by curious rotating movements of its pectoral fins, and the two median lobed fins, dorsal and anal, were also highly mobile. As the sun rose higher next morning the fish showed increasing signs of distress and sought to hide in dark corners of the boat. When Prof. Millot arrived from Madagascar at about 3.30 p.m. by special plane he was just in time to witness its last moments.

The islands, as Capt. Cousteau has discovered with his diving equipment, are surrounded by a steeply sloping basaltic sea bottom, so that it is not necessary to go very far from shore to find the depths at which *Latimeria* lives. At 140 fathoms light is very dim, even by day, yet it was at night that the fish was caught, and it may be that by day it lives deeper still. The distress of the captive under the tropic sun near the surface of the sea may have been due to the temperature, much higher than that to which it is accustomed, as well as to the brilliant light shining on its lidless, dark-adapted eyes. We do not yet know the mechanism by which it keeps a stream of water flowing over its gills, but if, like some fishes, it needs to keep swimming for this purpose, its confined quarters combined with the high temperature would have hastened its end. The gill-cover is only partly, and rather clumsily, ossified, and the photographs do not show any breathing-valves at the front of the mouth, so the mechanism for irrigating the gills may not be very efficient.

Latimeria's build, however, is not that of a powerful swimmer. In this it would be at no great disadvantage with the majority of its competitors in the twilight zone, where fusiform bodies and slender-stemmed forked tails are not the rule.

It is tempting to suggest that by adapting itself to life in the twilight zone *Latimeria* has managed to carry its archaic organisation through to the age of the Actinopterygian fishes. We do not yet know enough about conditions in this zone, but it is certain that it is less densely populated than the shallower coastal regions, and when a *Latimeria* has reached adult size it can have few enemies there. Its build, moreover, is like that of the large sea-perches which lurk in rock-crannies from which they surprise their prey.

SIGNIFICANCE OF COELACANTH STRUCTURES

Certain features show that the coelacanths parted company with the rest of the fish groups at a very early stage. The heart is an S-shaped tube, not so far advanced towards the compacted pump of the other vertebrates as even that of the sharks.

The spiral valve in the intestine is a feature shared with the more conservative Actinopterygian fishes, the Dipnoi and the sharks, but only the sharks and *Chimaera* have such a large and many-coiled valve as *Latimeria* (see *Nature,* vol. 174, p. 426). This is evidently an early device for securing a slow passage and a large absorptive area in the intestine and it is not understood why the modern bony fishes and the land vertebrates have abandoned it. Probably a longer intestine with rhythmic peristaltic movement is more efficient.

The retention of an unconstricted notochord and the lack of vertebral centra is, I believe, a primitive character too. It has been suggested that *Latimeria* is neotenic in this, that is, that it retains in the adult a feature characteristic of the young. But fossil adult coelacanths had no centra, many Rhipidistia had none, and in those that had them the centra were ring-like and more numerous than the muscle segments must have been, unlike the vertebrae of modern fishes and land animals, which are one to each segment and often elaborately articulated. The coelacanths adapted the notochord to adult life by strengthening its tough fibrous sheath. The arches of cartilage which bestride it above and below do not meet around it.

It can be argued that the replacement of the notochord by compact and calcified centra is a means of perfecting efficiency and precision in the swimming movements of the body muscles. At the point of evolution of the bony fishes at which the coelacanths arose this does not seem to have evolved, and the coelacanths, Rhipidistia and Dipnoi, specialised in narrow-based, mobile limbs. A glance through a series of pictures of fossil fishes shows that the correlation between the presence of centra and the shape of body and tail associated with efficient swimming is not complete. But the fishes without centra, except the specialised lung-fishes and the bottom-dwelling sturgeons, are now extinct, and the sea is dominated by fishes with hard compact vertebrae, often elaborately articulated. In comparison with the tail of a marlin, for example, the compressed tail-end of the coelacanths must be a feeble wagger, useful enough for steering.

The scales have retained an archaic structure.

The whole structure of the head is archaic. The cephalic extension of the notochord is now seen to be an essential part of the hinged (or kinetic) condition of the skull. The two points of attachment of the notochord and its freedom between them surely enable it to function as a shock-absorber in the struggles of the carnivorous fish with its prey. Romer's demonstration of the same arrangement in a Rhipidistian shows that it once characterised a whole group of fishes.

[Curiously enough, some modern Actinopterygian fishes (Stomiatoids) have secondarily freed the front parts of their notochords from bony centra apparently to the same end, absorption of shock. In them the notochord does not grow forward into the cranium, but functionally this part of the spine is incorporated into the head unit.]

The narrow-based, mobile limbs are of an archaic pattern, evidently near to that which made it possible for an

animal very like a Rhipidistian to crawl out of the water and found a land dynasty.

ADAPTIVE FEATURES

Latimeria is well adapted to a carnivorous life by its large size, large mouth, and by the pointed teeth lining its jaws, palate, "tongue", and gill-arches, in these resembling many another carnivorous fish. Both archaic and adaptive are the hinged skull and the cephalic notochord.

The dark-adapted eye and the reduced and fatty air-bladder are adaptations to life in deep water. Such an eye may be found in fishes of any lineage; and such reduction, or even elimination, of the air-bladder is an adaptation to deep-water life in other fishes whose ancestors possessed such an organ, the secretion of gas being a method of achieving buoyancy too expensive at the pressures that obtain in the deeps.

INDICATIONS OF SENILITY

The fact that there is more cartilage than bone in the brain-case and in the neural and haemal arches that bestride the notochord above and below is cited as typical of fishes "on the way out". It has been further maintained that cartilage is not and never was typically an adult structure, but is properly an adaptation to the actively growing embryonic and juvenile stages, and that animals carrying it on into the adult stage are neotenic. Such a hypothesis is difficult to prove or disprove, for argument is liable to run in a circle. The sturgeons are survivors of an ancient group of Actinopterygii and have the axial skeleton mainly cartilaginous. But, like *Latimeria*, they have plenty of bone in the dermal skeleton. It seems, too, that no completely bony coelacanth brain-case is known, so that the axial skeleton of coelacanths may always have included much cartilage. The deep-water fishes, too, commonly have rather watery tissues.

MAIN GROUPS OF FISHES: INTER-RELATIONSHIPS

The hinged cranium and cephalic notochord emphasise the closeness of the coelacanths to the Rhipidistia, with which indeed they have always been associated in systems of classification.

The brain shows affinity to that of Dipnoi, and both are close to the sort of brain that could develop into that of an amphibian, and so to the higher land vertebrates. We await further news of the venous system, the inner structure of the heart and aorta, and the skeleton and muscles of the limbs, to show how much we are justified in believing that the Dipnoi are close to the Rhipidistia, Coelacanthini, and land vertebrates.

Such features as *Latimeria* has in common with the Actinopterygian fishes, recall the ancient or archaically organised members of that group, and often characterise the sharks and Chimaeras too. Such are the spiral valve, the gular plates, the spiracle opening in front of the top of the hyoid arch, the structure of the gills, the heart apparently more primitive than in any surviving members of the groups. From the advanced Actinopterygii it is vastly different. The upper jaw, for example, has a fold of skin that looks like that over the maxillary bone of modern fishes, but there is no bone inside it. The gills of modern Actinopterygii have lost the septum that separated the front half-gill of an arch from the hind one. The vertebrae have ossified in Actinopterygii after their own pattern; the air-bladder in them opens usually into the dorsal side of the oesophagus or has become closed off entirely; their brain-case has developed a characteristic set of ossifications and has become pinched off between the eyes. Their venous system has followed its own lines. *Latimeria* has shown that to remain a fish it is not necessary to be a shark or an Actinopterygian; but it would have been better.

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THE INTERNATIONAL GEOPHYSICAL YEAR

MONTH BY MONTH

Compiled by Angela Croome

ANNÉE GÉOPHYSIQUE INTERNATIONALE
1957 1958
INTERNATIONAL GEOPHYSICAL YEAR

The IGY to Continue?

Should the IGY be prolonged beyond 1958? At a Press briefing in Moscow on March 19 a strong hint was given by several leading Soviet polar experts that an extension of the IGY as a whole or at least of the kind of co-operation that has characterised the Year would be welcomed by the Soviet Union.

Vasily Burkhanov, who is closely associated with the policy of the Soviet Arctic Institute and is a powerful figure generally in Russian polar affairs remarked that it was "commonly believed" that the time allotted for the IGY programme was "too short". The view was being privately expressed in a number of countries including the Soviet Union that it would be desirable to prolong the IGY as a whole and not only in the polar zones. A proposal to extend the period of the Year is one of the items on the agenda for the IGY Assembly to be held in Moscow this August. Soviet scientists were otherwise well pleased with the scope of the IGY programme and the effectiveness of co-operation upon it.

In President Eisenhower's release on American plans for exploring interplanetary space made at the end of March it was suggested that the pattern of international co-operation established during the IGY might, with profit, be extended to space research.

Preliminary Results

The Americans have been very prompt in sorting out and announcing the preliminary findings made possible by *Explorer I*'s instruments. The refined (and more useful) picture cannot be expected immediately, but, in the meantime, we are told that the average cosmic radiation intensity at orbital heights is about twelve times that at the Earth's surface (not serious for space visitors), that temperature fluctuation within the satellite is

FIG. 1. The *Navaho*, a long-range surface-to-surface guided missile being prepared for flight at the (American) Air Force Missile Test Centre, Cape Canaveral, Fla. The power plant which put *Explorer I* into orbit was developed during the *Navaho* programme.

TABLE OF MAN-MADE OBJECTS PLACED IN ORBIT TO DATE

Maker's Name	Astronomers' Name	Up	Down	Shape and Size	Orbiting Attitude*	INITIAL ORBIT: Period	INITIAL ORBIT: Distance from Earth	Orbital Life	All-up Weight	Pay-load	Used for (Inboard Research)	Principal Scientific Value	RADIO: Frequencies	RADIO: Radio Life	RADIO: Other Points
Sputnik I (instrumented sphere)	1957 α	Oct. 4 1957	Jan. 4, 1958	Sphere, 23-in. diam.	Spinning, 7 r.p.m.	96·2 mins	125 to 560 miles	92 days	184 lb.	184 lb.	Inside Air temperature	Ionospheric studies	40·002 Mc/s 20·005 Mc/s	3 weeks 3 weeks	— Intermittent 1 week
Sputnik I (nose-cone)	Not listed	Oct. 4, 1957	Yes. Not observed	Cone, 6 ft. long	—	96·2 mins	125 to 560 miles	—	—	None	None	None, since soon lost	None	—	—
Sputnik I (rocket case)	1957 α1	Oct. 4, 1957	Nov. 30, 1957	Tube, 24 ft. long	Spinning, nose-first	96·2 mins	125 to 560 miles	57 days	562 lb.	None	None	Meteor and aero-dynamic studies	None	—	—
Sputnik II	1957 β	Nov. 3, 1957	Mid-April, 1958	Cone, 30 ft. long	Spinning, nose-first	103·7 mins	170 to 1055 miles	5+ months	3/4 ton	1118 lb.	Living conditions in space, Cosmic rays, Solar x-rays	Living conditions in space	40·002 Mc/s 20·005 Mc/s	5 days	Signals ended prematurely
Explorer I (rocket case with instrumented nose-cone)	1958 α	Jan. 31, 1958	1959	Tube, 80 × 6 in.	Orien-tated	114 mins	219 to 1587 miles	One or more years	30·8 lb.	10 lb.	Inside and outside air temperature, Cosmic rays, Micrometeorites	Cosmic rays, intensity studies	108 Mc/s 108·03 Mc/s	2½ weeks 3 months	High-power Low-power
Vanguard I (instrumented sphere)	1958 β2	Mar. 17, 1958	1963 to 1968	Sphere, 6·4 in. diam.	Spinning	134 mins	404 to 2466 miles	5 to 10 years	3¼ lb.	3¼ lb.	Temperature differ-ence, inside and outside	Testing solar cells	108 Mc/s 108·03 Mc/s	2 weeks Indefin-itely while in sun	High-power. 6 silicon solar 'converters'
Vanguard I (rocket case)	1958 β1	Mar. 17, 1958	1963+	Tube, 48 × 20 in.	Spinning, nose-first	134 mins	404 to 2466 miles	5+ years	50 lb.		—	—	—	—	—
Explorer III (rocket case with instrumented nose-cone)	1958 γ	Mar. 26, 1958	Mid-April to July 1958	Tube, 80 × 6 in.	Orien-tated	115·7 mins	125 to 1735 miles	2 weeks to 4 months	39 lb.	12 lb.	As for *Explorer I* plus tape-recorder for cosmic ray data storage	Cosmic rays and meteor studies	108 Mc/s (tape-recorder) 108·03 Mc/s (tracking)	2 months 3 months	For tape; playback × 1 per orbit. Low-power

* This column must be considered tentative.

quite within the tolerance of a potential human space traveller (50°–80°F) though the sunny side of *Explorer*'s hull, outside, registers 250°F and the shadow side −200°F, and that the satellite has experienced negligible meteoric material in its path during the first month of its life.

The low-power transmitter (emitting signals on 108·03 Mc/s) has worked well and it was expected to last for the scheduled two or three months. The other transmitter ceased to be heard after about ten days—as had been expected—but, what had not been anticipated, resumed transmissions after a fortnight's silence and at full power. It is now silent.

Recovering News from Space

It is now becoming clear that it is one thing to get a satellite in the sky, and quite another to get a full yield of information back. The Americans have only succeeded in winning back 3% of the information being continuously radioed from the Army's *Explorer I*.

This is a poor return for the £1,400,000 invested. American sources calculate conservatively £140,000 per lb. in orbit for each Army effort and at least double that for every pound of orbiting Navy *Vanguard*. For a time there are only 13 lb. of data-collecting gear still in radio contact with Earth although there were four objects in orbit with a total all-up weight of 1760 lb.

The reason for the small yield compared with output from *Explorer I*'s telemetry system is that the coded signals were being broadcast continuously as the satellite looped the Earth, and there are not yet enough stations competent and equipped to pick up all the signals. Large gaps in the radio record are inevitably left between one station losing the signal and the next picking it up. In this case a miss is as good as several *thousand* miles. . . .

Incidentally it may be confidently assumed that the Russians have suffered quite as much as the Americans from telemetry losses from their first two *Sputniks*—perhaps more, proportionately, for the short life of the batteries drastically cut the useful length of the inboard experiments. Other factors to be taken into account, however, were the greater range of signal reception (due to the convenient frequency and high power of the transmissions) and—offsetting this again the huge area of the Earth swept out by the *Sputniks*, double that covered by the American satellites. The most convenient orbit from a tracking point of view is at 0°, along the Equator.

The Americans have from the first been alive to the problems of recovering satellite data. Two approaches have been adopted. Work on perfecting both solutions had been under way for more than a year before the first attempt to put an American satellite in orbit. One approach is incorporated in the miniature *Vanguard I* whose 108·03 Mc/s transmitter operates on solar batteries. The other approach was built in to the instrumentation of the short-lived *Explorer II* and is operating in the current *Explorer III*, in the form of a tape-recorder for storing the cosmic-ray information collected on each circuit of the Earth.

Satellite's Life in the Sun

There was not much scope for experiment in the 6·4-in. 3¼-lb. sphere that forms the *Vanguard I* test satellite that began orbiting on St Patrick's Day, but it contains one novelty and an important one. One of the transmitters is powered exclusively by energy from the Sun, making use of 6 silicon solar "converters" developed in a crash programme by the U.S. Army Signal Corps. The object of this ingenious expedient is to provide a long-lasting (though low-power) source of electricity appropriate for a satellite expected to stay up a considerable time. Micrometeorites permitting, there is really no reason why *Vanguard I* should not still be transmitting its radio messages five years from now—which is the *minimum* life predicted for it.

The original Signal Corps arrangement for operating one satellite transmitter on solar "batteries" envisaged a chemical storage battery of three months' life which would be trickle-charged from the solar cells while the satellite's path lay in the sunlight. When the storage battery was exhausted the solar cells when sunlit would operate the transmitter directly; the radio would be silent when the satellite

was travelling on the dark side of the Earth.

The extremely restricted payload of *Vanguard I* has precluded the storage battery from the system. The six solar cells therefore activate the transmitter only when they are in sunlight. But it appears that this is very much more of the time than might at first be thought; a preliminary estimate of the percentage of the satellite's life in the Sun gives 65%–75% and it may well prove higher.

The *Vanguard* launchers have made exhaustive computations of "sunlight life" of satellites at various orbital heights for launchings at every hour of the day throughout the year. A midsummer launching just before dawn in the semi-equatorial orbit to which the Americans are committed places the satellite in sunlight *all* the time. An equinoctial launching at seven in the morning (such as the successful *Vanguard* test) gives a sunlight life of not less than 65% on any one orbit.

Vanguard I's minimum height above the Earth (400 miles) is twice as high as the minimum for the orbits computed by Dr John P. Hagen and his team, so that the satellite will travel clear of the Earth's shadow for even more of the time than that estimated.

So much sun is clearly advantageous for a satellite containing batteries and very little else (as in the case of *Vanguard I*) but there is danger from overheating for the other types of instruments to be carried in the sophisticated, full-size satellites that are now awaited.

Equatorial Electro-jet Confirmed

Is the ionosphere always a diffuse cloud-like region where currents flow in complicated patterns or is it, in certain localities and at certain times, concentrated into something like a rope of current many hundreds of thousands of amperes strong, encircling the globe?

Unusually large variations of the Earth's magnetic field at Huancayo in Peru pointed to the possible existence of one such current system flowing around the Earth above the magnetic Equator. There is evidence also of similar systems in the Polar Regions. The IGY promised to give the opportunity of putting this hypothesis of the "electro-jet" (as such a current is called) to the test. The preliminary findings of two American groups in observing the variations in the magnetic field in the region of the Pacific where geographic and geomagnetic equators cross, seem to confirm at least the existence of the equatorial electro-jet. Local variations in the field-strength are an important factor in determining the existence of such a current. The strength of the current appears to be constantly changing, following more or less daily cycles, and the resulting fluctuations in the magnetic field and the manner in which they vary from point to point are important factors in determining the existence of the current.

Two components of the magnetic field (the vertical and the horizontal) are measured at ground-level. These components would be affected differently by the supposed current systems, depending upon the distance of the station from the magnetic Equator. At distant points the vertical components would be more affected than the horizontal, but as the Equator is approached, the situation would become reversed. On the Equator itself the effect would be confined entirely to the horizontal components. This would indicate that the current system lay immediately overhead and from the degree of local variation the strength of the current can be inferred. Readings from control stations in the vicinity which provide a species of triangulation help to fix more precisely the location and strength of the current in the sky.

Readings from a British station on Jarvis Island (one of the Line Islands) and those from an American station on Koror—both of them lying more or less on the geomagnetic equator—seem to correspond with this pattern and so make the existence of the electro-jet at the equator nearly certain. Readings from the control stations situated on islands lying a little distance away, north and south, tally with the main readings. The calculated height of the current above the surface appears to be in the region of 140 km., which confirms the theory of its relationship with the E-layer of the ionosphere. It is hoped that high-altitude U.S. rocket soundings will soon be able to give more precision both to the height and other values of this equatorial current.

Rocket-borne magnetometers were used by scientists from the State University of Iowa in investigations from ships both in the Arctic and the Antarctic at the end of 1957 to probe for the polar electro-jets. No conclusive results on these flights are yet available.

Is the Earth Within the Sun's Atmosphere?

On February 21 Prof. Sydney Chapman, F.R.S., initiator of the IGY and the chairman of its committee, presented to the Royal Astronomical Society a new theory on which he has been working. His theory suggests that the interplanetary space lying between the Earth and the Sun contains more material and is hotter than has been previously thought. This fresh approach considers the Earth as placed within the solar atmosphere which is envisaged as a progressively thinning gas extending almost indefinitely.

The implication is that the material between us and the Sun is several times denser than the 100 electrons per c.c. value usually given, and that the temperature climbs smoothly from the 1500°K that has been measured at the extremity of the ionosphere till it meets the 1 million degrees known to exist in the coronal gas close to the Sun's disc. (Data collected from rocket flights has suggested a model of the Earth's atmosphere which, in respect of temperature, stabilises at about 1500°K in the region of 400 km. above the surface and rises no further. A levelling-off of electron density is involved also since temperature and density are linked; it is this levelling-off that is now being questioned.)

In Prof. Chapman's theory, a steady output of hot gas from the solar furnace is matched by heat loss through thermal conduction through the gas, outwards. Work by Spitzer and Bates has established that heat can be observed flowing *downwards* beneath the uppermost layer of the ionosphere (the F2 layer) which cannot be accounted for solely by the energy absorbed in the layer. This is consistent with the idea of the Earth as a cool object moving through a hot gas, where the heat would tend to flow into our atmosphere from the Sun's.

Support for some of the elements in the theory is to be found in observations by astronomers of the solar corona, from radio echoes from the Moon, and from observations of zodiacal light—but not without some contradictions.

In due course, when there is an artificial satellite orbiting at a height of one Earth's radius away or thereabouts, confirmation should be available from this source. At present the strongest support for Prof. Chapman's model appears to come from the recent American work on "whistler" atmospherics (reported in these notes last September). For a radio path looping out to 30,000 miles or more guided by the lines of force of the Earth's magnetic field the electron density must be many times greater than that hitherto accepted.

Observing Zodiacal Light from Bolivia

Last month (April) two astronomers from the staff of the Cambridge University Observatories began an experiment on zodiacal light from the high-altitude station at Chacaltaya, Bolivia. This phenomenon which is caused by the scattering of sunlight by dust and electrons distributed throughout interplanetary space is exceedingly faint and therefore requires optimum conditions for observation. It is hoped that the dry winter months at Chacaltaya will provide these; the station stands at 17,100 ft. and above the densest layers of the atmo-

sphere which cause the greatest difficulties in astronomical observation.

The purpose of the expedition is to try and obtain observations giving a high resolution spectrum of zodiacal light. If this can be achieved it may prove possible to gain a better separation of the dust and electron components responsible for the scattering. This knowledge should definitely establish whether there is any gas in interplanetary space or not. This is one of the more controversial matters in geophysics at the moment.

Russians Halt Near Inaccessibility Pole

The Russian tractor train that has been pushing into the least explored region in the interior of Antarctica in extremely adverse conditions this season has halted for the winter. It is 400 miles from its destination, the so-called Pole of Inaccessibility, at 80° S, 50° E. The wintering station, called Sovietskaya I, is at 78°24′ S, 87°35′ E, and was established on February 16. It stands at 12,129 ft. (this is a first estimate, the figure may prove a little smaller or larger when final calculations are complete) but, in any case, Sovietskaya I easily qualifies as the highest wintering station ever set up in Antarctica. The Pole of Inaccessibility is thought to lie at a higher altitude still.

A similar sequence occurred last year with the setting up of Vostok, the Geomagnetic Pole station. After a considerable tractor-train haul during the 1956–7 season the Russians had to stop some hundreds of miles from their destination when the winter set in, and called the intermediate position Vostok I. They succeeded in attaining the correct position shortly after the beginning of operations this season.

The expedition towards the Pole of Inaccessibility this season has covered 1000 miles in specially designed snow-tractors from the point of departure, Mirny. There are twenty-seven men wintering at Sovietskaya.

Japanese Abandon Wintering Plan

After being beset for nearly two months in the ice approaches to Ongul Island the Japanese expedition in the *Soya Maru* was obliged to abandon the attempt to reach the Antarctic coast for this season. Supplies from the ship were ferried by *Beaver* aircraft to last year's wintering party still ashore, at the beginning of February. Assistance had already been requested of the Americans, but the ice-breaker *Burton Island* was not able to reach the *Soya* until the second week in February, by which time the ice in the area was no longer breaking up but beginning to thicken once more with the approaching winter. The only wise course was the hasty evacuation of the team manning the station and the withdrawal of both ships north to open water. Further delay might have trapped both the light expedition ship and the ice-breaker.

. . . And Belgians Beset on Way Out

Further along the coast westwards the Norwegian ships *Polarsirkel* and *Polarhav* which had carried the Belgian expedition and their supplies to Antarctica were caught in the ice on the return journey. At the beginning of February other expeditions were asked to help free them before winter set in. Before the U.S. ice-breaker *Burton Island* reached the area, the vessels freed themselves by their own efforts. They were able to proceed north into clear water by February 12.

Talking Across Two Auroral Zones

The five retiring members of Royal Society Base, Antarctica, reached England early this spring with several crates of scientific data for analysis.

The radio operator in the party reported that during the year's activity under his supervision, regular radio contact had been maintained with Mirny (U.S.S.R.), Showa (Japan), Ellsworth (U.S. Weddell Sea station), and the Norwegian base, and, less regular contact with Little America (Antarctic Weather Central), and other stations across the Antarctic auroral zone. Besides this, radio amateurs in fifty-six countries had been "worked" regularly and the Royal Society radio operators frequently carried out schedules across two auroral zones (that is, the Arctic zone as well as the Antarctic).

Signals from the first *Sputnik* had been picked up clearly and almost every transit had been observed. On the other hand, signals from *Sputnik II* were not once detected, in spite of full orbital forecasts from Mirny. Since the satellite's nearest approach to Halley Bay occurred in daylight it was not possible to check its passage by visual observations. (Current satellites are only visible when they are in sunlight as at dawn and dusk, when they show bright against a dark sky.)

Synchronised *Aurorae*

The simultaneous observations of the *aurora* in Northern and Southern Hemispheres which British scientists have been conducting for nearly two years (since the research programme at Halley Bay was initiated) have established definitely for the first time that displays occur at the same time in both auroral zones. It has also become clear that auroral displays approach nearer to the Equator in the Northern Hemisphere than in the Southern due to the tilt of the Earth's axis. Both features have been assumed for some time but conclusive proof has not before been available.

Prehistoric Life in Antarctica?

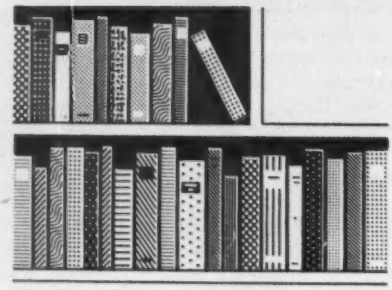
The Russians claim that they have found petrified remains resembling the bones of animals in rocks of the Antarctic mainland. During the late season research cruise by their large ice-vessel *Ob*, the ship's light aircraft made an excursion to investigate a sandstone outcrop on the coast of King George V Land. (This is the Australian segment that lies between Terre Adélie and the entrance to the Ross Sea; the site of the find, Horn Bluff, on Deakin Bay is roughly 69½°S, 150°E.) The geologists not only found that the sandstone contained up to 30% of garnet and "a considerable quantity of cassiterite" (the raw material of tin), leaf-imprints and carbonised pieces of wood dating from the Carboniferous period (roughly 200–250 million years ago), but also fragments of what may be bones, apparently dating from the same period as the vegetation.

It will probably take some time before the "bones" can be definitely confirmed as such and it may even be difficult to establish whether they are reptile, amphibian, fish, or what, though the implication is that they are vertebrate. No details are yet available of the fossils, and the significance of the discovery depends upon the amount of information that can be gleaned from the deposit—in other words how well preserved the "bones" are. Traces of a period of flourishing vegetation during the evolution of Antarctica have been well known since the early years of this century. One of Scott's expeditions detected the bony plates of fish but these date from the Upper Devonian period, roughly 300 million years ago. This is, however, the only previous trace of a vertebrate population of any kind in the area. It would be most exciting if the "bones" found by the Russians prove both dateable and identifiable thereby throwing light on a whole blank page of prehistory and pre-geography.

Japanese-Australian Co-operation

Australian ionospheric physicists on Macquarie Island, in the Antarctic, will be co-operating with scientists in Japan on the puzzle of the whistling atmospherics familiar to all radio operators. The theory is that these radio noises are caused by the electrical discharges generated by thunderstorms which travel to the other side of the Equator along the flux-lines of the Earth's magnetic field (*see* DISCOVERY, 1957, vol. 18, No. 9, p. 398). In order to study this phenomenon paired stations are required, one in the northern and one in the southern hemisphere as nearly as possible at the ends of a particular series of lines of force.

THE BOOKSHELF



The Crime of Galileo

By Giorgio de Santillana (*London, Heinemann, 338 pp., 30s.*)

Everyone interested in the history of the sciences should read this book. When I say "the history of the sciences", I do not mean the usual unconnected list of facts found in books known as the history of chemistry or the history of medicine, but the history of science as it fits into the background in which it was developing.

Prof. de Santillana tries in this book, as he says in the introduction, to show that there is nothing new in this world, but I am not sure that he succeeds. He strains at showing how present-day persecution of scientists is comparable with the persecution of Galileo, but to me it brings out something quite different.

Galileo, by his invention of the telescope, was able to confirm the Copernican theory of the relative importance of the Sun and the Earth. Whether or not Galileo's trial was brought about by his colleagues—if one might so describe the professorial class of that time—or whether he was in fact tried by the Papal authority, is somewhat beside the point; intrigue eventually meant that he was pilloried by the Church. Yet Galileo's statement showed that the effect of his discoveries on him, and their relation to his views on religion, was one which might well be followed today:

> "Galileo reminds his readers first that Scripture, although absolute and inviolable truth itself, has always been understood to speak figuratively at many points, as when it mentions the hand of God or the tent of heaven, and that it is our duty to understand it so that the two truths, that of God's Nature and that of God's Writ, never appear to be in conflict. Why, then, should Holy Writ be used to support the opinions of certain fallible philosophers against others, to the jeopardy of its authority? 'For who would set a limit to the mind of man? Who would dare assert that we know all there is to be known?' " (pp. 40 and 41).

The effect on our generation of the discovery of many more nebulae through the use of the radio telescope is one of smug self-satisfaction.

Galileo felt what many have felt since —that the best way in which to make his theories known was by making them intelligible to the layman. This is a lesson we could well remember these days and, to quote Prof. Trevor-Roper, any study which can only be understood by the expert is bound eventually to become so narrow as to be the property of a select class, and eventually to atrophy. Prof. de Santillana points out in this book that Kepler, with whom Galileo was in much correspondence, was quite unreadable, and it is well known that this fact retarded the value of Kepler's works for many a decade.

Galileo wrote in somewhat racy style, so that he might reach the layman, but Prof. de Santillana, in following this, has gone, to my mind, a little too far, and some of his expressions are nothing short of slang, which ill becomes a book of this sort. He has undoubtedly carried out a great deal of research in order to examine the trial of Galileo and the book is full of a good deal of material which is irrelevant. It is, in fact, too long. J. A. ORIEL

Exploring the Atmosphere's First Mile

Vol. I: Instrumentation and Data Evaluation. Vol. 2: Site Description and Data Tabulation. Edited by H. H. Lettau and B. Davidson (*London, Pergamon Press, 1957, x+578 pp., £7 per set*).

In the late summer of 1953, a multitude of scientists and technicians from the Cambridge Air Force Research Center (Massachusetts, U.S.A.) and many universities and institutes of technology, descended on a square mile of meadow in the open prairie country near the town of O'Neill, Nebraska. Their purpose was to study in detail the physical and mechanical processes that go on continuously in the "atmospheric boundary layer", the layer of air about 2000 metres in depth resting on the earth's surface. Separate teams from the various institutions had been allotted different tasks in the Great Plains Turbulence Field Programme at a symposium held some time previously, so most of the wide variety of instruments (thermo-couples, thermistors, heat flow-meters, pyrheliometers, radiometers, drag recorders, anemometers, and so on) which were installed at the field of operations had been tested and calibrated, though some were experimental and are described as "crude first models".

The experimental programme was mainly concerned with the vertical diffusion of atmospheric properties, assuming horizontal uniformity of the mean atmospheric properties.* It was for this reason of course, that the flat and uniform land surface of the Nebraska prairie was selected for the investigation; the maximum height differences over the square mile did not exceed three metres and the most prominent unbroken obstruction within ten miles of the site was a line of trees five miles away.

Volume I contains descriptions of the instruments and estimates of the accuracy of the measurements. Successive chapters deal with subsoil measurements (temperature, conductivity, and heat flux), interface measurements (radiation, boundary shear stress, dew deposit), mast profile data (variations in the vertical of wind, temperature, humidity, and ozone concentration), fluctuation quantities and free air observations (by radio sonde, aeroplane, and helicopter). The experimental difficulties, the inadequacies of some of the techniques, and the divergencies, sometimes great, between measurements of the same quantity by different instruments and experimenters are frankly discussed. The most urgent need in work of this kind is for instruments with rapid response; all the measurements of the vertical eddy heat flux using the Reynolds formula were unacceptable.

What must surely be the most comprehensive series of recordings of micrometeorological and turbulent fluctuations in existence is reproduced in Volume 2, in the form of summaries in tables; the complete data are available on punched cards. The tables are prepared for each of seven "General Observation Periods" of average duration of twenty-five hours, selected by the field co-ordinators as likely to provide favourable conditions for investigation, for example, clear skies to ensure a large diurnal variation of the heat-budget terms at the soil-air interface; constant wind direction; and, ideally, a significantly different mean geostrophic wind speed in each observation period so as to give a large range of Richardson numbers.

These books are sure to be consulted with profit by all engaged in micrometeorological studies but their cost is such that few will be able to afford a personal copy. J. PATON

* In the summer of 1956, the diffusion of SO_2 gas from a continuous point source was studied at the same site; the results of this work have not yet been published.

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The book belongs to the Industrial Innovation Series and carries an Introduction by Prof. G. C. Allen of University College, London. It is an important addition to the not very extensive literature about radio—a discovery less than 100 years old which now affects the daily lives of millions.

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Economics of Atomic Energy

By Mary S. Goldring (*London, Butterworths Scientific Publications, 1957, 179 pp., 30s. net*)

Hitherto the only books on the economics of nuclear power have been the detailed analyses by Schurr and Marschak and by Isard and Whitney, both of which were published several years before the Geneva Conference of 1955, that is before any but the most general information about nuclear power had been released and before a power-generating reactor had been built. The present book is, as far as I know, the first on the subject to come out since Geneva. It is a popular work, rather than scholarly in the manner of those just cited, but it gives an excellent general account of the matter.

The book is in three parts. Part I begins with a description of the British arrangements for manufacturing fissile material, followed by an outline of the basic scientific and engineering ideas and problems of nuclear energy and a discussion of the scale of investment required for the manufacture of weapons. Part II begins with a discussion of world demands, present and future, for power and the contribution that nuclear energy may make to satisfying them; this is followed by chapters on the costs of nuclear power in the United Kingdom and on the export market. In Part III the author describes the history and activities of the U.K. Atomic Energy Authority and the British nuclear power industry, and then discusses the methods adopted by other countries and, finally, Britain's future in the field.

This is essentially a personal book. Miss Goldring is an able and intelligent journalist who is also a trained economist. She writes from an independent standpoint, untrammelled by official connexions. Among the parts of the book that particularly struck me was Chapter 3, in which the author sets out to estimate, as well as she can from the scanty information available to her, the proportions of their national incomes which different countries have considered that they can afford to spend on atomic energy, and hence to deduce the extent of the nuclear-power programmes that other countries, especially smaller ones, can hope to tackle. The lesson the author derives from this argument is the plain advantage of international co-operation in development. In another interesting chapter Miss Goldring discusses the cost of generating power and particularly the justification for giving costs per kilowatt-hour to two decimal places. Part III also is a stimulating section of the book, though one sometimes wonders a little at the generalisations attributed to scientists.

Miss Goldring's conclusions on economic matters seemed to me to be always plausible and generally convincing. However, she is not so happy when she enters the field of physics. There are a number of technical inaccuracies throughout the book. Many of these are no more than irritants for the informed but some might mislead the non-technical. Thus on p. 10 plutonium is described as "an all-fissile material" in spite of its considerable capture cross-section. On p. 21 protons are confused with alpha-particles. On p. 22 it is said that fission can be caused only by neutrons "or intense heat"; spontaneous fission, it is true, is mentioned much later, on p. 86, but this latter reference is marred by the statement that the low proportion of uranium-235 in natural uranium is attributable to spontaneous fission although in fact this phenomenon occurs ten times as fast in uranium-238 and has in any event a half-life of 10^{17} years compared with 10^{9} years for alpha emission. In spite of errors of detail, however, Miss Goldring's general appreciation of the technicalities is good.

The author is a master of the striking opening paragraph and her style is always vigorous, though at times the adjectives seem to be oddly chosen (what is malevolent about the breeder reactor at Dounreay?). At a time when many non-technical books on atomic energy seem to treat the subject as an Eleusinian mystery rather than practical engineering, Miss Goldring's down-to-earth concentration on costs is salutary. Everyone interested in the subject will enjoy this book and find it worth while too. K. E. B. JAY

Light, Colour, and Vision

By Yves le Grand, translated by R. W. G. Hunt, J. W. T. Walsh, and F. R. W. Hunt (*London, Chapman and Hall, 1957, xiii+512 pp., 63s.*)

The subject of vision, small as it is by comparison with the whole field of science, is yet so vast that it is a great achievement to compress an adequate account of it within a single book. Nevertheless, Prof. le Grand has accomplished this, and indeed it is only occasionally that the reader is conscious of compression. Even then, the close documentation of the text with constant references to the literature makes it easy to expand any part by further reading in the original sources.

After a brief but adequate preliminary section on radiation and the general structure of the eye, the author proceeds to a detailed description of the practical capabilities of the eye as revealed by the photometric, colorimetric, and sensitometric measurements which have been carried out in great variety for many years. The story, as told by le Grand, is a fascinating one, but his skill as a storyteller is most happily combined with a teacher's enthusiasm for facts and figures. The result is a combination of textbook and reference book which is not only an economy in monetary outlay, but also in library space, an ideal desk book for every worker, scientific or technical, who is concerned with vision.

The chapters on colorimetry are particularly clear in their explanations of the mathematical calculations and transformations involved and are supplemented by full colorimetric tables in either text or appendix. The limitations of colorimetry are also made very clear in the chapters on the colour vision of real observers, normal and abnormal, and these chapters are likely both to inspire and to point the way for new researches on this most interesting subject.

Although the metrics of colour appear at first sight more complicated than do absolute and difference threshold measurements, a closer examination shows that threshold measurements are at least as puzzling as those of colour. The chapters on threshold measurements are, in fact, a little less clear and satisfying than those on colour measurements, and this is, no doubt, a reflection of the greater difficulty of this part of the subject. Incidentally, these chapters contain the only definite misconception which the reviewer has detected in the whole book: most of the other errors, few in number, are of a minor character, or misprints.

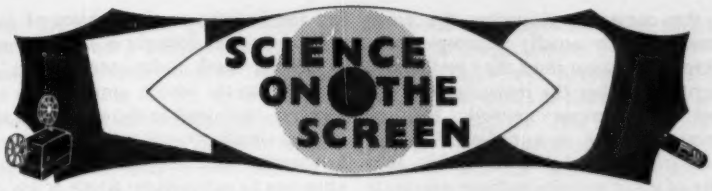
The last third of the book is concerned with theories of vision, prefaced by a careful account of the intimate structure of the retina. Chapters on photochemistry and electro-physiology lead on to the theory chapters proper, one on colour vision and one on thresholds. These last chapters, in spite of their inevitably provisional character (vision is far from being entirely understood yet) are nevertheless masterly in their clarity and fully uphold the standard of the earlier parts of the book. This clarity is doubtless of Gallic origin and the translators are to be most heartily congratulated on their success in retaining it in the English edition.

B. H. CRAWFORD

Brief Notes

The Ministry of Agriculture, Fisheries and Food have published their *Approved List 1957, Crop Product Approval Scheme*, and a record of current work on plant diseases and pests for September 1957, *Plant Pathology*, vol. 6, No. 3.

Report No. 13 of the Department of Nature Conservation has been published by the Provincial Administration of the Cape of Good Hope, Union of South Africa.



New BBC Series for Old

On February 4 the series "Eye on Research" was concluded, the whole series having run over some three months. The tenth and last programme was entitled, "The Thread of Life" (the titles have not always been the happiest of choices): it was the story of DNA (Deoxyribonucleic acid), which made a very grand finale to the course. It told of how the physicist with x-rays, the chemist with organic synthesis and analysis, and the biologist with direct experimentation on heredity have together worked out the part played by DNA in life processes.

The subject was, of course, formidable and was bound by its very nature to obscurity. Whether in fact this broadcast succeeded in clarifying much about DNA for the lay mind is very doubtful indeed. Yet it was an exciting broadcast and very well worth while, achieving an enormous amount.

A brilliant galaxy of talent was brought to bear. In the studio in London Sir Alexander Todd told what the chemist had achieved. Outside broadcasts and film were cunningly interwoven in what followed. First came the broadcast from Dr Ephrussi-Taylor in Paris, illustrating the control of bacteria with DNA; then we were taken to Cambridge, where Dr Ingram and Dr Brown made brave attempts to explain chromatography in a few simple words. After this, back to London for Sir Alexander Todd; then a switch to Dr Wilkins (also in London), who gave a very able account of how x-rays reveal crystalline structure; another switch to Prof. Waddington; and then off to Cambridge again with a discussion on haemoglobin. After this, a film from Dr Hamilton in New York, with brief indications of possibilities of cancer treatment with DNA (this film was much too technical, unfortunately). All the different contributions to the main theme were linked together in an easy manner by Prof. C. H. Waddington, who has already made a notable contribution to this series. The commentator, Robert Reid, took no effective part in this broadcast; it was all left to the professional scientists, and was all very exciting.

The broadcast ended with a summing-up and discussion from Prof. Waddington, emphasising the possibility of building up resistance to disease by introducing it into the cell as a heredity component, a concept of vast potentialities to health.

This whole programme, despite its over-technical content, was admirable and extremely powerful in showing how a multiplicity of international research forces is invariably brought to bear on one central problem, provided it is of sufficient importance. Whether the average listener really gained much factual knowledge (I am convinced he could not) is beside the point. The real triumph of the broadcast was the way in which it uncovered for the layman the basic outlook in pure research, and it did much to bring out the real excitement in scientific discovery. It was a most fitting conclusion to the series. If viewers emerge with the realisation that in research the man is infinitely more important than the equipment he uses, then a service will have been rendered to educating the layman to the meaning of science.

With the ending of this series, the BBC immediately began a new sequence of

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Oliver and Boyd

Tweeddale Court, Edinburgh 1

broadcasts in related vein on February 11, "Your Life in Their Hands". In some quarters this broadcast has raised quite a storm of protest. In many respects this new series is a continuation of "Eye on Research", although there are differences. Quite apart from content, which has been the subject of all the protests, the actual techniques employed differ from those we have become accustomed to in science broadcasting. The producer, B. Duncalf, has written in the *Radio Times* that these will be outside broadcasts, visits to hospitals, but with no actors or professional commentators, and that only the physicians and surgeons concerned with the techniques being described will contribute to the discussion.

Now in fact this was not quite the case on the first broadcast, for there was a most experienced and expert commentator. In fact, he was the "Doctor" who has appeared so very successfully in numerous "Question of Science" and related programmes. He spoke from London, while the broadcast proper was transmitted from the Churchill Hospital, Oxford, the subject-title being "The Breath of Life". This was not a very happy arrangement. Cross-conversations took place between the phantom voice of the *invisible* London commentator and the *visible* Oxford hospital director. It was rather confusing and quite unnecessary.

Then again there was far too much of Hollywood-style dramatisation: shots of long hospital corridors and pretty nurses approaching and passing the camera. From the viewpoint of the programme's content this was all quite pointless. One would have thought that a producer would treat as more precious the very small number of minutes allotted to science broadcasts. True, one can argue a case for bringing human interest into science, but surely not this way.

The subject selected was of grave importance, the treatment of those whose breathing mechanism had been paralysed by poliomyelitis and allied diseases. That the treatment was saving lives in a dramatic way was immediately obvious. The usual good animated diagrams were admirably exploited. The focus was on iron lungs and variants, and a really fascinating account of their successful application was given. Most impressive (and surprising) was the formidable character of the equipment used in this work of mercy.

However, I would agree with others that the exhibition of suffering patients undergoing treatment was in very bad taste. It was much more than pathetic, it was tragic, to see the highly strung, nervous, weak patients, with tubes inserted in their throats, smiling wanly and bravely into the cameras. Knowing the paraphernalia which usually accompanies a TV broadcast, what must they really have thought? Whether the televising of such scenes will increase neurotic fear of hospital treatment, as a medical writer in the *British Medical Journal* insists, is a matter of great concern to those who treat disease and it behoves the BBC to consult with them concerning any such broadcasts in future.

An impressive group of future programmes is planned for this series, including such subjects as treatment of cancer, tuberculosis, miner's pneumoconiosis, heart operations (film), brain surgery, and so forth. This is indeed a worthy and courageous project, but it is a programme easily capable of being wrecked if morbid interests are allowed to play any part, and this must be carefully watched by the programme organisers.

Patrick Moore has appeared in both of the astronomy broadcasts this month, one to adults, the other to children. In the monthly BBC broadcast "Sky at Night" (February 5) there was an interesting innovation: Mr Moore occupied about one-third only of the available fifteen minutes. Topical, as always, he took the radio detection of the new satellite *Explorer* (and, of course, the *Sputniks*) as an excuse for adroitly leading the listener to the subject of radio-astronomy. He brought in Dr R. Jennison of Jodrell Bank radio station who, in a simple manner with a small home radio receiver, explained in the clearest of terms the real significance to cosmology of radio-astronomy, and, naturally, gave special attention to radio-stars. Some of his illustrative material was very fine.

On February 14, in "Children's Hour", Mr Moore discussed stellar diameters. He introduced some admirable analogies, of the kind which would undoubtedly appeal to the young viewer. For example, he computed that an automobile travelling non-stop at 60 miles an hour would take no less than 1200 years to encircle Betelgeux. Mr Moore is an ideal lecturer to children. He is very intense (and children respond instinctively to intensity), he is always clear, and is most informative. Yet withal he deliberately restricts the actual content to a small amount (which is all to the good) and sees to it that he drives home his points emphatically. He talked engagingly about red giants, white dwarfs, and the enormous density of the dark companion to Sirius. A slight blemish here was a somewhat unfortunate description of stripped atoms, but this can be tolerated. Altogether, both these astronomical broadcasts were "star" programmes.

S. TOLANSKY

LETTERS TO THE EDITOR

Athanasius Kircher and the Magic Lantern

Sir:

Mr Barnes' reply to Dr Houston (DISCOVERY, 1958, vol. 19, No. 1, p. 37) is not sufficiently detailed to define conclusively what Kircher's contribution to the magic lantern was. Nor does he indicate who was its inventor, if not Kircher.

There were many inaccuracies among the statements made in the exhibition "Sixty Years of Cinema" sponsored by *The Observer*, and it is a pity that the confusion about Kircher was increased when the date of publication for his book "Ars Magna Lucis et Umbrae" was given as 1664 instead of 1646. Such mistakes do happen, of course, when non-historians attempt to write on the history of a subject. Another example is Dr Fraenkel's incomprehensible remark quoted in Dr Houston's article (*Science Progress*, July 1957) that "Kircher . . . converted the *camera obscura* into the magic lantern".

In his monumental work "Ars Magna Lucis et Umbrae", published in Rome in 1646, Kircher enumerates and illustrates for the first time various methods of projection by means of mirrors and convex lenses, with sunlight or candles or oil lamps. He was able to project to a distance of 150 m. writing and simple silhouettes, insects, and cut-out figures with movable arms and legs. By having pictures painted on the sides of an octagonal drum turned by a handle, he could also reflect from a mirror eight different images in quick succession. The various projection arrangements spread Kircher's fame far and wide, and his pupil Kaspar Schott relates in "Magia Optica" (1657) that by one of Kircher's methods Andreas Tacquet in Louvain illustrated the journey of the Jesuit missionary Martin Martini, recently returned to the Netherlands from China. This first record of a lecture illustrated by projected images proves at least (whether or not Kircher's projection arrangement had by then progressed into a magic lantern, which is doubtful) that it certainly was practicable.

Returning to Kircher's "Ars Magna", 1646, we also find illustrated in it a metal lantern fitted at one end with a concave reflector and at the other with a glass door, and containing a lighted candle at the focus of the reflector, the smoke escaping through a ventilator at the top. The purpose of this lantern (which was

already illustrated ten years earlier in Daniel Schwenter's "Mathematische und Philosophische Erquickstunden", Nürnberg 1636, p. 301) was to act as a kind of small searchlight for reading distant lettering by night, and also to perform various tricks. It was not difficult to combine this lantern with Kircher's projection arrangement by substituting a lens system for the glass door. However, the resulting magic lantern apparatus does not appear to have originated with Kircher. This much seems to be indicated by Kircher himself in the following passage from the second edition of "Ars Magna", Amsterdam, 1671, p. 768.

> "Many people, attracted by its novelty [Kircher's system], have applied their intelligence to developing this invention. Among them was the well-known Danish mathematician Thomas Walgenstein, who taking up my invention, described on p. 767, improved it, and sold it with much profit to several Italian princes, and the instrument has become quite common in Rome. It is, however, not really different from the lantern which we have described [see above], except for the arrangement of several pictures [on one glass slide]. Projected in a darkened room by Walgenstein, they were sufficiently sharp and clear, and met with the highest approval of the spectators."

Thomas Walgenstein was, however, not the originator of the magic lantern either. While studying at Leiden he became acquainted with Christian Huygens. Paul Liesegang, who devoted a lifetime to research on the history of projection apparatus, published correspondence between Huygens and his brother Ludwig (*Deutsche Optische Wochenschrift*, 1919, vol. 5) proving that Christian Huygens had designed a magic lantern about 1659. Considering it a trifle, Huygens failed to develop his invention beyond the experimental stage. It seems more than probable that Walgenstein had seen Huygens' magic lantern, and introduced it commercially. There is, at any rate, mention of Walgenstein's lantern, which he demonstrated and sold in Paris, Lyons, Rome, and Copenhagen, in a letter from Petit in Paris to Huygens in 1662 (Christian Huygens, "Oeuvres complètes", vol. IV., Letter No. 1078) and in Claude F. Milliet Dechales' "Cursus seu Mundus Mathematicus", Lyons, 1674.

We have seen from Kircher's remark that the magic lantern was popularised by Walgenstein in Rome, and it is therefore not surprising that the first book describing it (though without an illustration) should be "Centuriae Opticae", Part III, Rome, 1668, by the Roman mathematician and priest Francesco Eschinardi. In this work also appears for the first time the name "magic lantern".

Three years later Kircher published a correct description of the apparatus in the second edition of "Ars Magna". It has already been remarked both by Dr Houston and Mr Barnes that the two accompanying illustrations are faulty. The lens tube is erroneously depicted between the lamp and the glass slide, and the image on the slide is not inverted as it should be. But since Kircher's text is correct, the blame for these elementary mistakes must be laid on the engraver in Amsterdam, as Mr Barnes said. Kircher's book is illustrated with several hundred figures, in all probability he did not see proofs. It is equally remarkable that Joseph Priestley, referring to these two plates in his "History of Light", 1772, should have failed to notice the mistakes; he merely remarked on the artistic licence of the engraver in exaggerating the amount of smoke from the lamp. The lamp could, of course, never have been in that position; it would have obscured the concave reflector which the artist has omitted to draw, though it is quite clearly contained in Kircher's description.

Having, I hope, dispelled the mystery surrounding the invention of the magic lantern, I only wish to add that the first good illustration of a magic lantern is contained in Johann Christoph Sturm's "Collegium Experimentale", Nürnberg, 1676, on p. 164.* He mentions that he had introduced it as a novelty in a lecture at Altdorf University (where he was professor of mathematics) four years earlier.

The magic lantern with condenser lens (the form now generally used) was first described by the Irish amateur scientist William Molyneux in his "Treatise of Dioptrics", London, 1692, p. 183; but the principle of it is already indicated in Kircher's projection arrangement with a water-filled glass globe described in "Ars Magna", 1646.

Summing up, the notion that Kircher is the inventor of the magic lantern is as fallacious as the equally widespread opinion that Porta is the inventor of the *camera obscura*. They are due to the circumstance that both men did more for the dissemination of knowledge of these apparatus than any other writer. But the room type *camera obscura*, as I have pointed out elsewhere, was described by the Arabian scholar Alhazen who died in 1038, and the invention of the magic lantern must be credited to Christian Huygens about 1659.

* Even in this engraving the picture on the slide is not inverted. But this may well have been intentional, the author wanting the reader quickly to recognise his drawing of Bacchus' head on the slide; the slide itself is shown in another plate.

In view of the very strong attack upon Kircher which Dr Houston quotes from the "Allgemeine Deutsche Biographie", it seems necessary to reflect for a moment on Kircher's standing as a scholar and a writer. The numerous works which he published on an extraordinarily wide range of subjects (mathematics, optics, acoustics, musical instruments, medicine, natural history, philology, and hieroglyphics) show him as a man of encyclopaedic knowledge, to whose works practically every writer on these subjects in the 17th–19th centuries referred. In Rome he founded a famous museum of antiquities, the Musaeum Kircherianum at the College of the Society of Jesus. The fact that Kircher was a Jesuit may have prejudiced an anti-clerical writer in the "Allgemeine Deutsche Biographie". It is obvious that a scholar of such versatility is bound to be chiefly a compiler and disseminator of knowledge, who may sometimes bite off more than he can chew. Among the inventions attributed to Kircher by his contemporaries are the "Tariffa Kircheriana" (a kind of calculating machine), the Pantometrum Kircherianum (a surveying instrument), and the speaking trumpet. Kircher's theory of colours was the first to take into consideration physiological (subjective) colours, and he was the first to deduce that hieroglyphics are ideographs. To label a man of such wide and varied learning a "charlatan" discredits the user of that term rather than Kircher, however imperfect some of his pioneering work may be by modern standards.

HELMUT GERNSHEIM

Gernsheim Collection,
London.

The Philosophy of Synthesis

Sir:

I was astonished to read J. D. Agnew's letter in your September (1957) issue in which he sweeps aside all religion and states that laws of God are non-existent. In quoting Huxley as *his* bible, Mr Agnew seems to forget that Huxley, Hackel and the like have never in fact proved there is no God. The majority of eminent scientists throughout all decades not only are believers in the laws of God but are now finding that the same mathematical laws, valid in this planet of ours, are also valid for the whole cosmos—pointing to a single mind controlling the universe.

I recommend to J. D. Agnew an illuminating book on this subject written by Prof. A. Rendle Short, M.D., B.Sc., F.R.C.S., called "Modern Discovery and the Bible" (Inter-Varsity Fellowship, publisher).

H. BOYCE

Royal Naval Barracks,
Chatham.

FAR AND NEAR

Second Geneva Atom Conference

The British Government has accepted an invitation from the Secretary-General of the United Nations to participate in a second International Conference on the Peaceful Uses of Atomic Energy, from September 1 to 13, 1958.

The provisional agenda agreed to by the seven-nation Advisory Committee covers all aspects of the peaceful applications of atomic energy. The President of the Conference is to be Prof. F. Perrin of the Commissariat à l'Energie Atomique de France and the Secretary-General, Dr S. Eklund of Sweden.

Two atomic energy exhibitions will be held in Geneva during the Conference. The first of these will be a scientific exhibition under the auspices of the United Nations, at the Palais des Nations. The other, which will be commercial, is the International Exhibition on the Peaceful Uses of Atomic Energy, at the Palais des Expositions.

The U.K. delegation is expected to consist of five delegates, about 250 advisers, and about 250 observers, the advisers being drawn primarily from among the authors of papers. The leader of the U.K. delegation will be Sir John Cockcroft, Member for Scientific Research of the United Kingdom Atomic Energy Authority. The other four delegates are expected to be a second representative of the Authority and representatives of the Royal Society, British Industry, and the Medical Research Council.

It would be most helpful if all people interested in attending the Conference as observers would apply for passes as soon as possible, and in any case not later than April 19, 1958. Representatives from industrial firms who are working in the atomic energy field should apply to Mr M. H. L. Whitehouse, Nuclear Energy Trade Associations' Conference, 32 Victoria Street, London, S.W.1, and all others to Mr J. C. Walker, United Kingdom Atomic Energy Authority, St Giles Court, St Giles High Street, London, W.C.2. (After March 10, 1958, the United Kingdom Atomic Energy Authority's address will be 11 Charles II Street, London, S.W.1.)

Training Space Dog

Physiologist Ada Kotovskaya, who prepared Laika for her world-famous flight, is now training another dog, named Alpha. If everything goes well with the training, Alpha will perhaps make a trip in another Soviet sputnik.

Dr Kotovskaya told a correspondent of

FIG. 1. Soviet physiologist, Mrs Ada Kotowskaja, seen with "Alpha", who will probably succeed "Laika" in the new Russian satellite projects.

FIG. 2. Two U.S. Air Force researchers in upper atmosphere medicine check the health of two monkeys who took a recent rocket flight 37 miles into the stratosphere. The reactions of the monkeys were recorded and much significant data was added to scientific knowledge of the possible reactions of humans to rocket flight in outer space.

Soviet Woman that the information obtained by scientists indicates that living organisms can survive in space-flight conditions.

Another woman scientist, Dr Lydia Kurnosova, and her colleagues have designed improved types of instruments for the study of cosmic rays.

The instruments, which are now undergoing tests, are an ionisation chamber and a counter designed on the principle of "Cherenkov radiation".

Whereas the counter in the second *Sputnik* could only measure the intensity of cosmic radiation, the new instrument will be able to distinguish between and analyse different kinds of particles.

Dr Kurnosova took part in the Barcelona International Astronautical Congress last year.

Endeavour Prizes

As a contribution to the meeting of the British Association for the Advancement of Science to be held in Glasgow on August 27 to September 3, 1958, Imperial Chemical Industries Limited, publishers of the quarterly scientific review *Endeavour*, have offered the sum of 100 guineas to be awarded as prizes for essays submitted on a scientific subject. As the primary purpose of these awards is to stimulate younger scientists to take an interest in the work of the British Association and to raise the literary standard of scientific writing, the competition is restricted to those whose twenty-fifth birthday falls on or after June 1, 1958.

The awards will be: a first prize of 50 guineas, a second prize of 25 guineas, a third prize of 15 guineas, and two special prizes of 5 guineas for competitors who have not passed their eighteenth birthday on June 1, 1958. The subjects for the essays are as follows:

1. Education for an age of science.
2. Rockets and satellites and their scientific significance.
3. Photography and cinematography in science.
4. Chemicals from petroleum.
5. Darwinism today.
6. The measurement of time.

The essays, which must be in English and typewritten, should not exceed 4000 words in length, and only one entry is permitted from each competitor.

All entries should be addressed to: The Assistant Secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1.

The envelope should be clearly marked "*Endeavour* Prize Essay". The latest date for receipt of entries is June 1, 1958. The essays will be judged by the editor of *Endeavour* in consultation with representatives of the British Association. The successful competitors will be invited to attend the whole of the Glasgow meeting, at which the prizes will be presented, and their travelling expenses within the United Kingdom will be paid. The judges' decision is final, and the right is reserved to withhold all or any of the prizes should no entries of sufficient merit be received.

The essays must be submitted without signature. The competitor's full name and address and date of birth should be disclosed in a sealed covering letter attached to the essay and addressed to the Assistant Secretary of the British Association, who will acknowledge all entries. The names will not be disclosed to the judges until after the prize-winning essays have been selected.

In judging the essays special attention will be paid to the originality of the approach to the subject, and great importance will be attached to literary style. The competitor's age will also be taken into account. The essay winning the first prize will be published in *Advancement of Science*, journal of the British Association.

Magneto-Aerodynamics for Rockets and Satellites

At a recent meeting of the National Academy of Sciences (U.S.A.), the Director of the Graduate School of Engineering at Cornell University, Dr William R. Sears, described how magneto-aerodynamics may provide the means for the safe return of artificial satellites to the Earth's surface.

Magneto-aerodynamics is concerned with the partial ionisation of air that occurs when objects pass through it at extremely high speeds, notably during the re-entry of rockets and satellites into the Earth's atmosphere. As friction and compression heat the air in front of the object to very high temperatures, the air becomes a conductor of electricity when the atoms of which it is composed release free electrons.

According to research at Cornell, this conductivity can be further increased by "seeding" the air near such a high-speed body with a small amount of an easily ionisable substance such as sodium or potassium. At speeds of Mach 12 to 14, a state of conductivity several times better than salt water may thus be induced. If this technique can be worked out, and if magnetic field strengths comparable to those of permanent magnets can be provided in flight, electric currents will be set up by the motion of the air, and significant forces can be applied directly to the airstream.

In the case of a satellite re-entering the atmosphere at high speed, the electromagnetic relationships will resemble those of an electric generator. The hot, seeded air, being a conductor of electricity, takes the place of the windings of the generator armature, while the magnetic field emanating from the satellite in flight will supplant the generator's fixed field. As the satellite plunges back into the atmosphere, the moving of this hot-air "armature" across the magnetic field of the satellite will generate an electric current.

Just as torque tends to retard the armature of an operating generator, so will the air flowing past the missile tend to be decelerated. This retarding effect may prove useful in slowing down satellites to prevent their overheating as they enter the atmosphere.

An even more interesting application of the principles of magneto-aerodynamics may occur in the acceleration, rather than the deceleration, of the conductive airstream. In a description of these possibilities, Dr Sears said:

"To do this will require the use of electric fields as well as magnetic, for now the analogy is not with a generator but an electric motor. If an electric field can be applied across hot, seeded air by means of electrodes, a current will flow. Again the combination of a current and a magnetic field gives rise to a force, but in this case it can be directed so as to accelerate the airflow. This should provide a unique method of accelerating gases to extremely high speeds; for example, in the tail pipe of a rocket. According to our studies the speeds thus attainable are theoretically unlimited. Moreover, this magneto-aerodynamic rocket can have constant cross-section, and therefore can avoid some practical problems of conventional rockets."

Cambridge Underwater Expedition to Apollonia

The Cambridge University Underwater Exploration Group will travel to Apollonia, Libya, in August to investigate the submerged Greek harbour dating from 500 B.C. Apollonia was a coastal town with a perfect natural harbour, and was the commercial port of the capital city of Cyrene. The area was first colonised by the Greeks, then taken over by the Romans, inhabited by the Jews, overrun by the Arabs, and eventually sank into the sea. Since much of the town is well preserved underwater, it is of great archaeological interest.

The team will consist of ten trained aqualung divers, all of whom are specialists in other work as well. Some are archaeologists and geologists; one is a zoologist, another a doctor, and there are two underwater cinephotographers, a draughtsman, and a writer.

The diving equipment will consist of six 80 cu. ft. aqualungs, and an air compressor. It is hoped that the area of the sunken city will be surveyed accurately,

and a "town plan" produced. The method will be a modification of a naval method of beach surveying, which involves measuring lines on reels strapped to the diver's chest. The measurements will be made from heavy sinkers, positioned accurately from the shore by rheodolite.

All objects of archaeological interest will be examined, and Mr Goodchild, Director of Antiquities in Libya, will be near by to give expert advice. Various odd underwater features will be examined geologically to discover if they are natural faults in the rock or man-made. It is hoped that the original water-level and the date and nature of the subsidence will be determined accurately. The deep water beyond the old coastline will also be searched for wrecks.

Exchange with Mexico Needed

In the "Progress of Science" note (DISCOVERY, 1957, vol. 18, No. 7, p. 282) on "New Shapes in Architecture", an exchange of ideas and technical knowledge between the Cement and Concrete Association in London and such rapidly growing countries as Mexico and Brazil was recommended. A walk round the streets of Mexico City today, several months after the severe earthquake sustained in the city last summer, shows how sound was the suggestion. The effects of the earthquake were at first reported to be severe, but in fact the loss of life was relatively small. However, the full damage was not known until some weeks later, when cracks and faults in structure were discovered in many buildings that had apparently withstood the earthquake well. The tragedy is that many buildings of architectural merit, such as the Office of the Public Registry (a building influenced by Corbusier), are now looking sadly the worse for their shaking.

How excellent it would be if the sound structural knowledge which is the result of years of research by the Cement and Concrete Association could be exchanged for some of the vitality visible in the domestic and public architecture of Mexico.

Changes at the N.P.L.

During 1957 a comprehensive review of the organisation and programmes of work of the National Physical Laboratory was carried out by a committee of the Research Council of the Department of Scientific and Industrial Research. As a result, the Research Council have now approved certain changes in organisation, which will become effective about the end of March.

One of the most important is a reorganisation of the work at present carried out in the Divisions of Electricity, Metrology, and Physics, and in the Test House. These four units will be replaced by three new Divisions to be called Standards, Applied Physics, and Basic Physics.

Rainmakers Bring Some Relief

While wheat-growers and pastoralists are counting the rising cost of the drought which has affected most of the Australian Continent, artificial rainmakers have produced some good falls in parts of drought-stricken Queensland and New South Wales, where the first worth-while rain for six months fell after rainmaking teams of the Scientific and Industrial Research Organisation spent two hours seeding cloud formations. Falls of up to two inches were reported in the Bundarra area, about sixty miles north of Tamworth.

Similar success for the rainmakers is reported in the Dawson and Callide valleys of Queensland, where again falls of up to two inches have been reported. These valleys have been scarred by bush fires in the wake of drought, and farmers say the rainmakers have saved them from further heavy stock losses.

Widespread rains have relieved drought conditions in the north of Western Australia, in what is believed to be the forerunner of the wet season in the north. Nearly two inches of rain fell at Marble Bar, Australia's hottest and driest town. It was the heaviest October rainfall on record and also the first time in twenty years that rain had fallen in Marble Bar in October.

TV Helps Ice Reconnaissance

Russian aeroplanes in the Arctic have been using television for ice reconnaissance on the northern sea route.

A TV camera with an observation angle of about 45°, installed on a plane, transmits a picture of the ice conditions ahead to a TV screen on the bridge of a Russian icebreaker.

There is also a special device for showing the temperature of water and ice.

The camera covers a strip of about three miles—quite enough to enable the ship's captain to pick the best route through the ice.

New UNESCO Headquarters Decorated

Four more artists, invited to decorate the new UNESCO headquarters now under construction in Paris, are: Afro (Italy), Karl Appel (Netherlands), Roberto Mata (Chile), and Rusino Tamayo (Mexico). This announcement was made following a meeting in Paris of the Committee of Art Advisers for the Construction of the Permanent UNESCO Headquarters. The work was to consist of paintings or murals of varying size for the decoration of the seventh (top) floor of the building, where the restaurant and cafeteria are situated.

Other world-renowned artists who had already agreed to execute works for the new headquarters are: Jean Arp, Alexander Calder, Juan Miro, Henry Moore, Isamu Noguchi, and Pablo Picasso. These works of art were scheduled to be completed in time for the opening of the new headquarters about the middle of this year.

Royal Astronomical Society's Geophysical Journal

The *Geophysical Journal* is the successor to the Geophysical Supplement of the Monthly Notices of the Royal Astronomical Society. The Society believes that there is a need to expand the scope of the former publication, in order to provide an outlet for the many papers resulting from the expanding activity in geophysics. While there are journals catering for atmospheric and terrestrial physics and for oceanography, there is no English journal appearing regularly that publishes fundamental work in such subjects as geodesy, gravity measurements, seismology, geomagnetism, and the physics of the Earth's interior.

The History of Italian Science

The scope of Italy's contribution to science over the past eight centuries is revealed in an exhibition now touring Italian cities, organised by the "Ente Manifestazioni Milanesi" of Milan, where it was shown during the month of January.

The exhibits are arranged so as to show the high-lights of achievement in all branches of science during each century, together with documents, portraits, manuscripts, and illustrations of cities and events which give the historical background of the period.

Starting with the introduction of Arabic science into Italy by Leonardo Pisano in the early Middle Ages, the display traces the discoveries of the great explorers like Marco Polo, Christopher Columbus, and Amerigo Vespucci. Leonardo da Vinci's scientific researches are represented as well as the mathematical discoveries of Scipione dal Ferro, of the Bologna School, with whom Copernicus worked at the beginning of the 16th century.

Eleven panels illustrate the life and activities of Galileo, and among the objects included in this section are copies of the telescopes through which he discovered the satellites of Jupiter in January 1610, and the sunspots shortly afterwards.

Other panels record the achievements of Galvani, who made the first experiments with electric current, and Alessandro Volta, whose electric battery opened up the field of electrochemistry; the great Italian school of mathematicians including Cremona, Beltrami, and more recently

Enriques; Lombroso, founder of criminal anthropology; Pacinotti, whose name is linked with the invention of the dynamo; and Marconi, Nobel prize-winner, whose signals sent across the ether introduced the era of radio.

The exhibition includes the work of Enrico Fermi, another Nobel prize-winner, whose researches in nuclear physics up to the time of his death in 1954 laid the foundation for much of the work now being achieved in this field.

Development Station Opened

To extend their activities in the chemical engineering and automatic control fields, the firm of John Brown Ltd has recently established a research and development station at Leatherhead, Surrey.

The primary object of the station will be to undertake sponsored development work on behalf of Government Departments and industrial organisations, and also for their own engineering and construction divisions. It will cover the following fields:

(i) Process development and investigation of chemical engineering problems.
(ii) Development of automatic control systems and their application.
(iii) Special problems of nuclear engineering.

The new station has a site of four acres and is equipped with laboratories and pilot-plant buildings. Special attention has been given to facilities for development work requiring large-scale pilot-plants, which the company, through its construction division, is well equipped to build.

The station has started with a staff of thirty, consisting of chemical engineers with experience in process development work, of automatic control engineers, and of supporting staff for chemical, physical, mathematical, and design work.

Electronics for Eye Research

An electronic machine for research into the functions and diseases of the eye has been completed in Sydney after ten years' work. The machine, designed by members of the Physiology Department, is known as a multi-beam ophthalmoscope. It can shoot a fine beam of light into a selected part of an eye and trace the reaction of an individual cell or part of a cell. The head of the Physiology Department, Prof. Bishop, said that very little was known about the workings of the eye.

German Nuclear Research Centre at Karlsruhe Under Construction

Constructional work at this first research reactor (FR2), completely designed and developed by German industry and engineers, has now started. The reactor foundations have been laid and the first buildings are being erected.

In its special issue, "Atomforschungszentrum Karlsruhe" (December 1957), the magazine *Die Atomwirtschaft* is for the first time reporting comprehensively on many technical details of the reactor. Those authoritatively participating in this project have written papers on the plans, construction, measurement, and control methods, on the fuel element production for this 12 MW heavy-water reactor with natural uranium, as well as on security and waste water elimination problems, selection of the location of the reactor site, and the tasks and organisation of the institutes.

Furthermore, the interesting organisation of the reactor station, which is being financed partly by the Federal Government and partly by private industry, has been described.

Ambassador

At the instigation of His Excellency the Portuguese Ambassador, Dr Pedro T. Pereira, and through the good offices of Almirante Thomas, the Portuguese Minister of Marine, two models of caravels of the type used by the Portuguese and Spanish explorers in the great age of discovery, have been made by the Museu de Marinha of Lisbon, as gifts to the National Maritime Museum.

Each of the models is about three feet long overall. They were placed on exhibition in the museum directly after the presentation, and form part of the special exhibition of wooden shipbuilding now occupying two galleries in the East Wing. With them are the famous picture of the Portuguese Carracks, which formed one of the most interesting features in the exhibition of Portuguese art at the Royal Academy two years ago.

"English Electric" Nuclear Reactor Simulator

The English Electric Company Limited has developed a simple computer which simulates the performance of nuclear reactors under variable operating conditions, thus making it possible to familiarise future operators with the "feel" of reactor control systems. Universities, technical colleges and atomic training establishments can thereby provide themselves with the equivalent of a nuclear reactor packed in a cubicle only 6 ft. high and 2 ft. wide, and at a minute fraction of the cost.

This analogue machine has been fully engineered and is "operated" from a small panel of indicating meters and controls. It was originally designed by the Company's Atomic Power Division, for training its own personnel on the operation of various nuclear reactor designs, including that for Hinkley Point.

It comprises three computing sections, nuclear reactor, heat transfer, and excess reactivity, all joined on a closed loop circuit into which can be injected certain required signals. There are selector switches for setting up various conditions relating to control-rod movement, fuel, neutron source, coolant mass flow, gas inlet temperature, and in fact, to all the variables which are needed to assess the behaviour of nuclear reactors under operating conditions.

A New Transformer Plug

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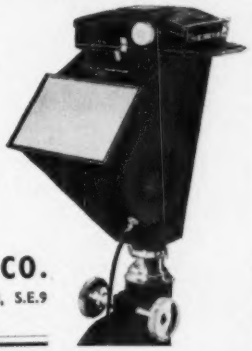

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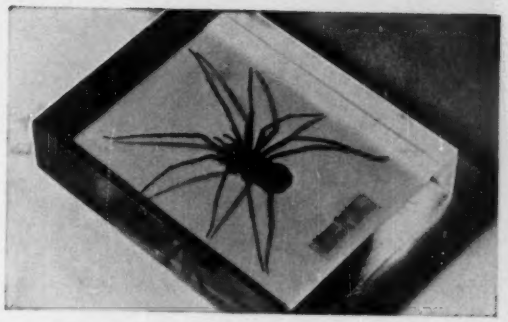

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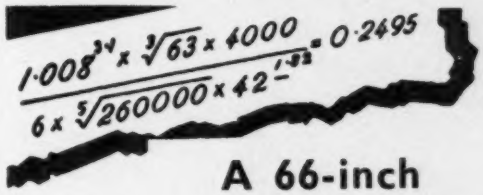

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